Attendance trends threaten future operations of America's state park systems

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This research examines how the operating expenditures of America's state park systems will be affected by a continued growth in attendance consistent with observed trends as well as potential climate futures. We construct a longitudinal panel dataset (1984–2017) describing the operations and characteristics of all 50 state park systems. These data are analyzed with a time-varying stochastic frontier model. Estimates from the model are used to forecast operating expenditures to midcentury under four different scenarios. The first scenario assumes annual attendance within each state park system will continue to grow (or decline) at the same average annual rate that it has over the period of observation. The subsequent scenarios assume statewide annual mean temperatures will increase following the RCP2.6, RCP4.5, and RCP8.5 greenhouse gas emissions trajectories. Operating expenditures under a scenario where annual growth in attendance stays consistent with observed trends are forecasted to increase 756% by midcentury; this is an order of magnitude larger than projected expenditures under any of the climate scenarios. The future climate change scenarios yielded increases in operating expenditures between 25% (RCP2.6) and 61% (RCP8.5) by 2050. Attendance is the single largest factor affecting the operations of America's state park systems, dwarfing the influence of climate change, which is significant and nontrivial. The future of America's state park systems will depend upon increased support from state legislatures, as well as management actions that generate funds for the maintenance of existing infrastructure and facilities, and the provisioning of services.

climate change | stochastic frontier | outdoor recreation | public lands

Parks and protected areas are vitally important to the health and well-being of the American public. These areas have also shaped the nation's identity as pioneers of preservation and conservation, leaving a legacy that many other nations around the world have aspired to over the past century. Managing parks and protected areas for human enjoyment and benefits comes at a cost, however. Management requires capital to ensure visitors' health and safety and to maintain infrastructure and services that facilitate desired outdoor recreation activities. Importantly, capital is also required to take management actions that minimize the environmental disturbance visitors can have on natural landscapes and cultural resources. As the demand for outdoor recreation continues to grow across the country, so too do the costs associated with managing outdoor recreation destinations.

Visitation to parks and protected areas across the United States has increased substantially over the past half-century; despite slight declines in the 1990s and early 2000s, many parks are now experiencing record high visitation (1, 2). This has led to many well-publicized claims that the nation's national and state parks are being "loved to death." Annual visits to the nation's national parks, for example, increased by 33% from 1984 to 2017 (3); current visitation is over 330 million. By comparison, attendance across the nation's 50 state park systems increased 25.6% over the same period of time, with an all-time high of 807 million visits in 2017 (4). Concerns about increases in visitation to national parks frequently make national news, particularly in times of crisis such as federal government shutdowns. However, there is a dearth of information about visitation to state parklands across the country; despite the fact they see nearly 2.5 times as many annual visits as national parks. Currently, there are a total of 8,292 individual management units in operation within one of the nation's 50 state governments (5). These state parklands generate over 2 billion hours of nature recreation annually, about a third of all US nature recreation (6).

Increased visitation to parks and protected areas often stresses the capacities of park managers to ensure visitor health, safety, and enjoyment. Increased visitation also often results in greater, or more severe, environmental disturbances on-site as well as new disturbances in adjacent areas that visitors are using to avoid crowded trails and waterways (7). All of these consequences result in increased management costs. It is unclear whether elected officials across the country are willing to prioritize these costs, and support them through federal and state appropriations dedicated to managing outdoor recreation. For example, state funding allocated to managing outdoor recreation through state park systems has declined from a high of $3.74 billion (inflation adjusted) in 2006 to $2.59 billion in 2017 (4).

To compound concerns over attendance levels that are rapidly outpacing appropriated budgets, there are a wealth of data suggesting climate change, and more particularly increases in temperatures, will positively influence visitation rates (8, 9).

Significance

State park lands in the United States are important to the health and well-being of the American public. Managing these lands for human enjoyment comes at a cost, however. Management requires capital to ensure visitors' health and safety, to provide infrastructure and services that facilitate desired outdoor recreation activities, and to protect natural and cultural resources. By constructing and analyzing a dataset describing the operations of all 50 state park systems in the United States, we were able to determine the operating costs of state park systems will likely increase substantially in the coming decades. These increases are largely attributable to continued increases in attendance (visitor-hours) and, to a much lesser extent, climate change.

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Research specific to the United States has projected annual attendance levels to parks and protected areas will increase as temperatures rise (10, 11).

Despite concerns over both increased visitation to parks and protected areas across the United States and the influence of climate change on visitation, no previous research has tied these trends to the actual costs associated with managing parks and protected areas. The purposes of this research are to (*i*) determine whether observed attendance and climate have influenced the operating costs of the nation's 50 state park systems, and (*ii*) project future operating costs out to midcentury for each of the state park systems under different scenarios focused on historically consistent projected attendance levels as well as different greenhouse gas emissions trajectories. Our analysis uses state-level data for each of the nation's 50 state park systems from 1984 to 2017. We fit these panel time-series data with a time-varying stochastic frontier model and then link the derived estimates to state-level attendance projections that are consistent with trends observed over the past 34 y. We also use the model-derived estimates to project the operating expenditures required by each state park system at midcentury under three different greenhouse gas emissions trajectories (RCP2.6, RCP4.5, and RCP8.5).

Results

The Cost Efficiency of America's State Park Systems. Results from the baseline model revealed that attendance, capital expenditures, revenue, and labor are all significantly related to the operating expenditures of America's state park systems (Table 1). Summing the estimated coefficients across these outputs yields a value of 0.768, suggesting, by-and-large, the state park systems are doing a good job at operating in a cost-minimizing fashion. A value of 1.0 would indicate constant returns to scale across all of the state park systems. The average marginal effects for each of the output factors from 1984–2017 are shown in Fig. 1. Changes in attendance yield the greatest increases in operating expenditures; on average, a 1% increase in attendance costs a state park system an additional $26.16 per acre. As visitation to a state park system increases, managers have to utilize more resources to enforce rules and regulations, maintain facilities, and provide for visitor services. Labor ($10.12), revenue ($7.78), and capital expenditures ($6.08) are less elastic relative to attendance.

Results from the stochastic frontier model also revealed considerable heterogeneity in the cost efficiency of the state park systems (*SI Appendix*, Fig. S1). Cost efficiencies are estimated through the stochastic frontier model (*Materials and Methods*) and range from 0 to 1, where a value of 1 indicates the theoretical minimum ratio between operational expenditures and the outputs of production.

The Influence of Temperature and Precipitation on Operational Expenditures. Results from the reestimated model, including state-specific climate covariates, are shown in Table 1. All of the output factors were still significantly related to operating expenditures; a recalculation of average marginal effects revealed they were consistent with those previously estimated. The model also revealed annual mean temperature was positively and significantly related to operating expenditures. The warmer the year, the more it costs to manage a state park system. This

Table 1. Results of the stochastic frontier model fit to the longitudinal panel dataset (1984–2017)

Variable	Coef.†	SE‡	Avg. marginal effect, $§
Base cost inefficiency model			
ln Attendance (visitor-hours)/acre	0.255***	0.014	26.16
ln Capital expenditures/acre‡	0.027***	0.004	6.08
ln Revenue/acre‡	0.064***	0.007	7.78
ln Labor (person-hours)/acre§	0.422***	0.015	10.12
Constant	3.087***	0.062	
U^{σ} constant	−3.407***	0.092	
V^{σ} constant	−3.479***	0.059	
θ constant	0.329***	0.020	
σ_U	0.182***	0.008	
σ_V	0.176***	0.005	
λ	1.037***	0.012	
Base cost inefficiency model with state-specific climate covariates			
ln Attendance (visitor-hours)/acre	0.250***	0.015	25.43
ln Capital expenditures/acre‡	0.027***	0.004	6.07
ln Revenue/acre‡	0.064***	0.008	7.76
ln Labor (person-hours)/acre§	0.425***	0.016	10.20
Precipitation, cm/y	$2.5e^{-4}$	$3.6e^{-4}$	93.73
Average temperature, °C	0.003*	$1.7e^{-3}$	11.51
Constant	3.097***	0.069	
U^{σ} constant	−3.401***	0.092	
V^{σ} constant	−3.485***	0.059	
θ constant	0.319***	0.023	
σ_U	0.183***	0.008	
σ_V	0.175***	0.005	
λ	1.043***	0.012	

*$P < 0.05$, ***$P < 0.001$; $n = 1,700$ (50 states × 34 y); number of pseudorandom draws used in each model = 250.

†All estimated coefficients can be interpreted as point elasticities, meaning they indicate the percentage change in *ln* Operating Expenditures given a 1% increase (decrease) in that coefficient's respective variable.

‡Confidence intervals are provided in *SI Appendix*, Table S1.

§Average marginal effects are the monetary change in operating expenditures corresponding to a 1% increase (decrease) in each variable; they are calculated as $\bar{x}^{\beta} \times \ln(\bar{x})$, where $\bar{x}$ is the variable mean.

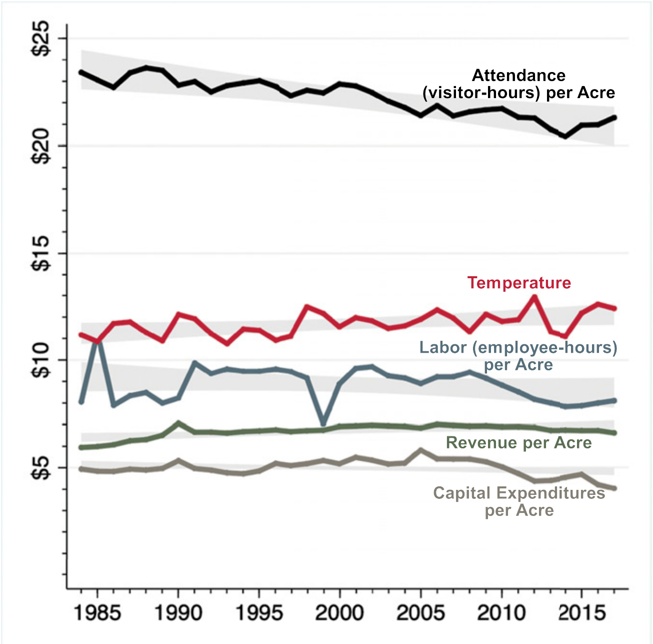

Fig. 1. Estimated average marginal effects by year across all 50 state park systems. Average marginal effects are the change in operating expenditures per acre attributable to a 1% increase in the variable of interest.

finding is logical given that the majority of state park systems experience seasonal variations in the types of activities they support and the amount of parkland they actively manage. On warmer years, state park systems appear to be supporting high-use activities (typically those occurring in the summer) or keeping parks open for longer periods of time. The average marginal effect for changes in temperature revealed that for every 1% increase in annual mean temperatures, operating expenditures are expected to increase by $11.51 per acre. Across all 50 state park systems, we observed substantial variation in cost sensitivities to increasing (or decreasing) temperatures (Fig. 2). The operating expenditures of state park systems at lower latitudes are more sensitive to increases in temperatures relative to those at higher latitudes. Of the five significant covariates, attendance had the largest average marginal effect on operating expenditures for most states; however, temperature had the greatest effect on operating expenditures for Alaska, Texas, Louisiana, and Florida.

Annual precipitation was not significantly related to the cost of operating a state park system. Precipitation may not be related to operating expenditures at the annual scale due to its high temporal variability. More precipitation than expected does not necessarily mean that management activities are reduced; they are likely just shifted to dryer times of the day, month, or year.

Forecasted Operating Expenditures. The first scenario we explored assumed temperatures will stay constant at 2017 levels, but attendance to each state park system will continue to change at an annual rate consistent with trends observed between 1984 and 2017. Across all 50 state park systems, annual attendance increased by an average of 6.66% per year over this 33-y period of time. If historical rates of annual changes in attendance remain consistent with observed trends, average operating expenditures per acre in 2050 will be $5,380.29 per acre; this is an order of magnitude greater than current average operating expenditures ($432.00 per acre).

The remaining three scenarios assume attendance will remain constant at 2017 levels, while temperatures will increase to varying degrees following the RCP2.6, RCP4.5, and RCP8.5 greenhouse gas emissions trajectories (12). Under the RCP2.6 trajectory, average operating costs are expected to increase to $581.00 per acre, a change of $149.00 relative to current average operating expenditures. Under the moderate emissions trajectory (RCP4.5), this value increases to $614.31 per acre, a change of $182.31 relative to current average operating expenditures. Forecasted operating expenditures under the highest emissions trajectory (RCP8.5) are $670.28 per acre, a change of $238.28 relative to current average operating expenditures (Table 2). There was significant variation in forecasted estimates across the 50 state park systems under each of these scenarios; this is a product of the large variation in expected temperature changes across the states.

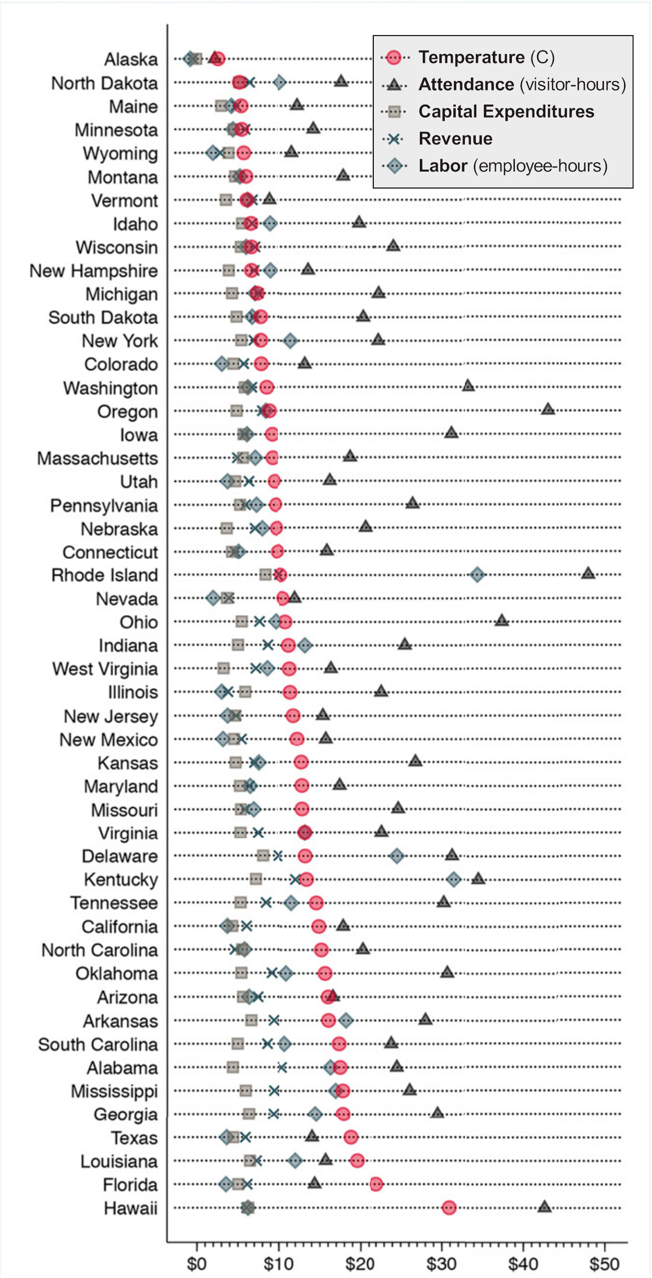

Fig. 2. Estimated average marginal effects by state (1984–2017 average). Average marginal effects are the change in operating expenditures per acre attributable to a 1% increase in the variable of interest.

Table 2. Projected costs of managing US state park systems

Scenario	$USD per acre in 2050	Δ 2017–2050	Aggregate costs for all 50 state park systems in 2050, billion $USD	Δ 2017–2050, billion $USD
Growth in attendance	5,380.29	5,023.29 (+1,407%)	47.88	42.29 (+756%)
Climate change				
RCP2.6	581.00	223.99 (+63%)	6.99	1.40 (+25%)
RCP4.5	614.31	257.30 (+72%)	7.61	2.02 (+36%)
RCP8.5	670.28	313.28 (+88%)	9.00	3.41 (+61%)

Collectively, these findings suggest climate change, specifically an increase in annual mean temperatures, will increase the cost of providing outdoor recreation opportunities and managing parkland. However, the increased costs attributable to climate change are marginal relative to the costs associated with continued increases in attendance. Attendance to state park systems is the predominant factor driving the operating costs associated with maintaining existing infrastructure, facilities, and services.

Discussion

The costs associated with managing and maintaining outdoor recreation resources on state park lands in the United States are substantial. In 2017, the annual operating expenditures for all 50 state park systems was $2.59 billion dollars, $170 million dollars more than the total operating budget for the US National Park Service (13). This research examined how these costs will be affected by a continued growth in attendance consistent with observed trends and potential climate futures. Within the nation's state park systems, the cost of providing services to ensure visitors' health and safety and maintaining outdoor recreation infrastructure (trails, trailheads, campgrounds, etc.) is affected by the amount of demand placed on those systems (i.e., attendance) and annual mean temperatures.

Demand-induced costs are to be expected. As a park system experiences more visitor-days, management must dedicate additional resources to managing the outdoor recreation amenities offered by their state park system. For state park systems that manage more "natural" settings like trails, rivers, lakes, and campgrounds, as use increases trails and roads need to be maintained more frequently, restroom facilities need to be cleaned more often, and more environmental monitoring is needed to ensure sites are not being degraded beyond acceptable levels. Demand-induced costs are also seen in state park systems that offer "developed" outdoor recreation activities like lodges, golf courses, and ski areas. However, for these systems, demand-induced costs are more likely to be caused by providing basic services (access, sanitation, and safety) as well as maintaining equipment (e.g., vehicles, ski lifts, etc.) and paying overhead costs (e.g., utilities). Our analysis revealed that attendance had the most elastic influence on operating expenditures, with a 1% increase in attendance inducing an average of $26.16 per acre of operating costs, an effect substantially larger than the other output factors we investigated. There is substantial variation in cost sensitivities to shifts in attendance with some states like Rhode Island ($47.98 per acre), Oregon ($43.00 per acre), and Hawaii ($42.59 per acre) seeing the largest increases in operating costs as attendance fluctuates (Fig. 2). This variation is likely attributable to the amount and types of recreation infrastructure in different state park systems. Ancillary analysis revealed a significant and positive correlation between the extent to which a state park system was focused on "developed" outdoor recreation and sensitivities to fluctuations in attendance (*Materials and Methods*).

Before this investigation, the relationship between the costs of maintaining parks and protected areas and climate had not been examined. Research into other public goods and services, such as health care, agriculture, and water resources, has found that increases in temperatures may impose additional operational costs (14). Our investigation determined temperature, but not precipitation, is positively related with operating costs. Over the past 34 y, we estimate that for every 1% increase in annual mean temperature, America's state park systems have seen an $11.51 increase in operating expenditures per acre. We found the operating expenditures of state park systems at lower latitudes are more sensitive to increases in temperatures relative to those at higher latitudes. This is likely attributable to the fact parks in warmer climates are more costly to manage (15). While this is true, the more rapid rates of warming expected at northern latitudes (16) may result in warming having a larger actual impact in northern states.

The operating expenditures of four state park systems in particular—Alaska, Texas, Louisiana, and Florida—are more sensitive to annual mean temperatures than any other variable we examined, including attendance. For Alaska, this may be the product of managers having to maintain infrastructure that deteriorates more rapidly as freeze/thaw events become more common, combined with the limited capacity of the system to experience large increases in attendance during the winter months in which daylight is limited. By comparison, Texas, Louisiana, and Florida may be more sensitive to annual mean temperatures given that their low-lying parklands require more maintenance as they become inundated more frequently due to sea level rise (17).

Across most of the country, future climate change will result in a continued expansion of the high-use summer season (10); this expansion will be accompanied by increased operating costs. For the three greenhouse gas emissions trajectories we examined (in which all other output factors were held constant), the average cost of maintaining outdoor recreation opportunities provided by state park systems will increase between $149 per acre (RCP2.6) and $238.28 per acre (RCP8.5). Aggregating these costs across all 50 state park systems, we expect total operating expenditures between $6.99 billion (RCP2.6) and $9.00 billion (RCP8.5) by 2050 (Table 2). These findings are logical, as warming results in state park system managers keeping their systems open for longer periods of time and, for some geographic locations, having to mitigate the undesirable impacts rising temperatures can have on infrastructure and natural resources.

It is important to note that our analysis only captures the climate-related costs incurred solely by state park systems; it does not capture other costs that may be borne by other state and federal entities aside from state parks. As an example, rising temperatures will likely increase the frequency and severity of fire on state parklands; the costs associated with suppressing these fires is incurred by state and federal fire agencies. Our estimates should be interpreted as a lower bound of total cost of climate-related impacts to state parklands.

While operating expenditures are expected to increase substantially under any of the plausible future climate scenarios, the magnitude of these increases are small relative to those expected under a scenario in which historical attendance trends (1984–2017) persist until midcentury. Under this scenario, operating expenditures would reach $47.88 billion by 2050, more than five times those expected under the RCP8.5 scenario (Table 2). Given historical attendance trends and a projected increase in the US population by 19.5% from 2017 to 2050 (18), we believe these future attendance increases to state parks are plausible, if not likely. We doubt the operating expenditures of the nation's state park systems will approach \$50 billion given that state legislatures often prioritize other public services over environmental conservation and the provisioning of outdoor recreation opportunities (19). Currently, an average of only 0.16% of the states' operating budgets are appropriated for the operation of state park systems [range: 0.05 [Wisconsin] – 0.54 [South Dakota] (5)].

Our results suggest a dire future for America's state park systems. Attendance has consistently grown over the past three and a half decades. If this trend continues into the future, state legislatures will face very difficult decisions about how to ensure their publics can continue to receive the social and cultural ecosystem services provided by parklands. If the states fail to increase annual appropriations to their states' park systems, specifically mandating those funds support the maintenance of existing infrastructure, facilities, and services, the quality of outdoor recreation opportunities and the environmental quality of state parklands will decline.

A scenario that is likely to play out in many states will be an increased demand for state park systems to generate enough funds through entrance fees, permits, donations, and other sources to supplement state-appropriated operating budgets. Many state park systems have already begun to take management actions specifically for the purpose of revenue generation. For example, both Colorado and Wyoming have implemented state park entrance fee increases in 2019, with Wyoming implementing a peak-use pricing scheme (20, 21). More innovative solutions include statewide policy changes such as excise taxes on outdoor recreation equipment (22), the direct funding of individual state park units by corporations within the outdoor recreation industry (23), the selling of unique license plates that serve as annual entrance passes (24), and partnering with local communities in comanagement arrangements (25).

The future of America's state park systems will depend upon the continued, and likely increased, support from state legislatures as well as management actions and policy solutions that generate funds that can be used specifically for the maintenance of existing infrastructure, facilities, and services. More research is needed to determine which management actions (e.g., increasing fees, implementing peak-use pricing, etc.) or policy changes (e.g., excise taxes, etc.) state park visitors and the general public are willing to support. Most states will likely need a combination of both management actions and policy changes to maintain the quality and services currently offered by their park systems. In the search for this appropriate mix of management actions and policy solutions, we urge state legislatures, state park system directors, and other decision makers to not price-out large portions of their constituents who are unable, or unwilling, to support park maintenance through increased fees. Doing so is likely to displace these individuals or prohibit them from obtaining the benefits provided by parklands (26, 27). Applied research from the social and economic sciences is needed to ensure future generations of the American public can enjoy the benefits currently provided by state park systems.

Materials and Methods

Data Collection. In the United States, state park systems are areas of unique biological, cultural, economic, or recreational value that are managed by state governments (19). Most commonly, these areas are managed under the direction of a statewide divisions of wildland resources or departments of parks and recreation. Each individual area is managed for one or more purposes, depending up the enabling legislation that established the area. These management units consist primarily of lands designated as "state parks" (2,184 units; 26.3% of all units); however, they also consist of lands designated as natural areas (827 units; 10.0%), recreation areas (800 units; 9.6%), state forests (648 units; 7.8%), state fish and wildlife areas (600 units; 7.2%), state historical areas (581 units; 7.0%), scientific areas (105 units; 1.3%), and environmental education areas (24 units; 0.3%). Generally, these areas are managed to (*i*) preserve and protect native ecosystems, natural landscapes, and biodiversity in general; or (*ii*) produce marketable commodities such as timber and livestock to support local economies; or (*iii*) provide the public with access to passive and active outdoor recreation opportunities (19).

We constructed a longitudinal panel dataset characterizing the management and use of all 50 state park systems between 1984 and 2017. Each year, representatives from each state provided us with data on annual attendance, expenditures, revenues, employment, as well as a variety of other descriptive metrics. The data are compiled in annual reports (28).

Our analysis of cost efficiency comprised six variables for each state park system and each year: (*i*) operating expenditures, (*ii*) attendance, (*iii*) capital expenditures, (*iv*) revenue, (*v*) labor, and (*vi*) acreage. Operating expenditures are recurring payments made for goods and services to operate and maintain a state park system. Funds for operating expenditures come from state general funds, dedicated funds, federal funds, park-generated revenue, and other funds such as interagency transfers and money generated through temporary leases. Operating expenditures do not include labor-related expenditures (i.e., salaries and wages); this information is reported independently during data collection each year. Attendance is the total amount of visitor-hours spent in state parks; this value was estimated by multiplying the total count of day and overnight visits to both fee and nonfee areas by an average visit time of 3.0 h [this value is derived by dividing the 2.2 billion hours of outdoor recreation that all 50 state park systems generate annually (6) by the average annual attendance rate across all 50 state park systems over the past 34 y (734,252,207)]. Capital expenditures are nonrecurring expenditures used to improve the productive capacity of a state park system. Most often, these are for land acquisition, park improvements, and new construction projects. Revenue is money generated from use fees and charges; this includes entrance fees, camping fees, cabin/cottage rentals, lodge rentals, group facility rentals, restaurants, concessions, beaches/pools, golf courses, and other sources such as donations. Labor is the total amount of employee-hours spent managing a state park system; this value was derived by taking the total count of full-time, part-time, and seasonal employees who maintain, operate, and protect a state park system, and multiplying it by 2,080 h per year.

We collected historic climate data for each state park system from the National Oceanic and Atmospheric Administration's National Centers for Environmental Information program (https://www.ncei.noaa.gov). Historic climate data consisted of statewide annual mean temperatures and statewide annual precipitation. Projected climate data were obtained from the ensemble projections generated through the Coupled Model Intercomparison Project, phase 5 (CMIP5) (29). CMIP5 projections were compiled for three future greenhouse gas emissions scenarios: (*i*) RCP2.6; (*ii*) RCP4.5; and (*iii*) RCP8.5 as reported in ref. 30. Projected data were derived by estimating a linear trend between 2017 statewide mean temperatures and midcentury CMIP5 estimates.

Data Analysis. We fit a time-varying stochastic frontier model to the longitudinal panel dataset. The model is specified as follows:

$$ox_{it} = \beta_1 a_{it} + \beta_2 cx_{it} + \beta_3 r_{it} + \beta_4 l_{it} + u_{it} + \varepsilon_{it}, \quad [1]$$

where the subscripts i and t refer to each state park system and each year. The model regresses operating expenditures (ox) onto attendance (a), capital expenditures (cx), revenue (r), and labor (l). The stochastic frontier model provides the theoretical foundation of cost minimization (31, 32). We assume the managers of state park systems are attempting to minimize operating costs while maximizing attendance, capital expenditures, revenue, and labor. Cost inefficiencies are captured in the composed error term $u_{it} + \varepsilon_{it}$, which includes both random disturbance and a one-sided "stochastic" disturbance representing inefficiency. Before estimation, all monetary variables were adjusted to 2017 dollars using the US Consumer Price Index. Additionally, all of the variables were normalized by the acreage of each state park system (for each year) and transformed into their natural log. We fit the model using Greene's (33) true random-effects specification, which allows us to differentiate time-varying inefficiency from unit-specific time-invariant unobserved heterogeneity. Time-invariant unobserved heterogeneity may be present within the data given environmental and policy contexts vary notably across the 50 states [e.g., the ecological characteristics of a state have been shown to influence the operating expenditures of state park systems (15)]. After fitting the baseline model specified above, we refit the model including the historical climate data as additional independent variables. We checked the robustness of coefficients estimated with the true random-effects specification by comparing them against estimates generated by a variety of other specifications commonly used to fit time-varying stochastic frontier models (*SI Appendix*, Table S1). Coefficients derived through the true random-effects specification (with an exponential inefficiency distribution) were not substantially different (−3.3/+9.7%) than estimates derived through other specifications (*SI Appendix*, Table S2). These models were fit with the sfpanel command in Stata 15.0.

We tested the exogeneity of each independent variable, excluding the precipitation and temperature variables, using random-effects instrumental variable estimators (34). This involved first fitting pooled ordinary least-squares regressions in which each independent variable was regressed against a suite of instrumental variables consisting of all other outputs of production. We saved the residuals generated by these models and subsequently included them in augmented equations, which regressed operating expenditures on the outputs of production; these models were specified with SEs clustered by state. We failed to reject the null hypotheses that each independent variable was exogenous ($P \geq 0.196$). The augmented equations used to test for exogeneity were fit with the xtreg command in Stata 15.0.

We estimated state-specific average marginal effects for each independent variable. Average marginal effects are the monetary changes in operating expenditures corresponding to a 1% increase in each independent variable; they are calculated as $\bar{x}^{\beta} \times \ln(\bar{x})$, where $\bar{x}$ is the state-specific mean of each variable.

We conducted an ancillary analysis on the estimated state-specific average marginal effects, correlating them with Davis' measure of the extent to which a state park system offers "developed" outdoor recreation opportunities (ref. 19, table 7). The correlation was positive and significant ($r = 0.30$, $t = 2.19$, $P = 0.03$).

We forecasted operating expenditures under four different scenarios. The first scenario assumes the annual attendance to each state park system will continue to grow (or decline) at the same average annual rate that it has over the period of observation (1984–2017) while annual mean temperatures remain constant at 2017 levels. The subsequent scenarios assume attendance will remain constant at levels reported in 2017, but statewide annual mean temperatures will increase following the RCP2.6, RCP4.5, and RCP8.5 greenhouse gas emissions trajectories. Forecasted operating expenditures were derived by calculating the percentage change in both annual mean temperatures and attendance between 2017 and 2050, and then multiplying this value by the previously estimated state-specific marginal effect.

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