Tourism Response to Dark Sky Conservation at the Great Sand Dunes National Park and Preserve*

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*Please refer to the research article “Contingent Behavior Modeling for Dark Skies Valuation at Great Sand Dunes National Park” by the authors for scientific details and updated results.

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Executive Summary

The Great Sand Dunes National Park and Preserve is designated as a Gold Tier International Dark Sky Park, the highest level of classification granted by DarkSky International. With the benefit of cultural, natural, and educational significance, the park has put forth substantial effort in updating lighting infrastructure, creating educational programs, and collaborating with adjacent communities to conserve the night sky. This report presents our findings estimating the local tourism benefits of preserving dark skies in the Great Sand Dunes National Park and Preserve.

In October 2023, we surveyed 367 visitors at the Great Sand Dunes National Park and Preserve about their past spending and visitation, as well as their future behaviors if the park's night sky becomes less dark. The dark sky, allowing views of the Milky Way rising over the sand dunes, greatly enhances the visitation experience. Forty-seven percent of the respondents indicated that they would reduce their future visitation if the night sky at the park became less dark. If the park's night light increased slightly to the level of nearby Alamosa (zip code 81101), the average visitor would reduce their visits by 0.02 days over the next five years. If it increased to the level of Breckenridge (zip code 80424), they would reduce their visits by 0.03 to 0.04 days.

Visitors spend an average of $80 per day at the park. With approximately 500,000 recreation visits annually, increased night light pollution could lead to significant tourism revenue loss for the local region. If the park's night light were to increase to resemble that of Alamosa (zip code 81101), there would be a direct loss of between approximately $176,000 and $191,000 in local tourism revenue per year. If it increased to the level of Breckenridge (zip code 80424), the loss would be between approximately $272,000 and $295,000 per year. Furthermore, each dollar of reduced direct tourist spending has ripple effects throughout the regional economy. Using a multiplier of 1.10 for the Great Sand Dunes region, this translates the $175,000 - $191,000 reduction in tourism revenue (for the Alamosa night light scenario) to an annual regional GDP loss of about $190,000 - $210,000. For a Breckenridge night light scenario, the $272,000 - $295,000 in reduced tourism revenue is estimated to result in an annual regional GDP loss of about $299,000 - $325,000.

Each day spent at the Great Sand Dunes brings significant happiness and value to visitors. Although harder to quantify, we estimate that the net benefit to visitors is multiple times their daily spending. Conceptually, net recreation benefits for consumers (visitors) are larger than visitor expenditures because visitors value their recreation at a level over and above the costs they incur. Similarly, losses in net visitor benefits due to potential increases in night light pollution are estimated to be larger than the associated losses in direct visitor spending. If the night light at the park were to resemble that of Alamosa, then we project a decrease of between approximately $708,000 and $2.9 million in net consumer (visitor) benefits per year. For an increase in night light pollution to the level now seen in Breckenridge, we project an annual reduction in net visitor benefits of approximately $1.1 million to $4.5 million.

Our estimates for lost local spending and net consumer benefits due to potential night light pollution are conservative. We do not account for future increases in baseline visitation over the coming years due to expected trends such as increased population sizes. In addition, our survey does not consider potential future first-time visitors who may want to visit because of the dark skies but may choose not to if the skies were to get brighter.

Background

Preserving dark skies has become an important aspect of nature conservation. In 2022, the Governor of Colorado signed the "Support Dark Sky Designation and Promotion in Colorado" Act (HB22-1382, 2022). The 2023 Conservation in the West Poll, conducted by the State of the Rockies Project, revealed that 69% of respondents see dark sky preservation as a key conservation goal (State of the Rockies, 2023). Many studies highlight the ecological benefits of dark skies, such as protecting wildlife, preserving biodiversity, and reducing energy waste. However, there is still a gap in research on the economic value of dark sky tourism. Understanding this economic value can strengthen the ecological arguments for preservation and offer a new perspective on nature conservation.

Since 2019, the Great Sand Dunes National Park and Preserve (hereafter, the park) has been designated as a Gold Tier International Dark Sky Park by DarkSky International. The park's high elevation, dry air, and remote location make it ideal for stargazing. Achieving and maintaining this designation requires significant effort and cost, including updating and monitoring lighting infrastructure, creating public-facing dark-sky educational programs, and working with neighboring communities in Alamosa and Saguache Counties to reduce light pollution (DarkSky International, 2019).

Our project aims to quantify the benefits to tourists and the increases in local tourist spending associated with dark sky conservation at the Great Sand Dunes National Park and Preserve. The park attracts over half a million tourists annually, contributing more than $30 million to the local economy in 2022 (Flyr & Koontz, 2023). Given the investment required to preserve dark skies, understanding how much of this revenue comes from dark sky tourism is crucial.

We conducted onsite in-person surveys with visitors to the park. Our survey instrument gathered a wide variety of information on the visitors, their trip-taking behavior, and their expenditure during travel and while in the local area. We also asked them about their perceptions of the quality of the night sky at the park and whether they have spent time there looking at the night sky. Importantly for this study, we also asked visitors to compare the quality of the night sky at the park to that at their residences and asked how changes in the night sky at the park might affect their future trip-taking behavior. Using statistical methods, we then estimated the changes in annual local spending and net consumer (visitor) benefits if the night sky at the park were to become less dark. Our findings provide the first concrete data on how

dark skies affect tourism behavior and support ongoing efforts to protect and preserve dark skies in the region.

Survey Methodology

The consumer value of a commodity sold in the market can be easily approximated by its price, as the price is jointly determined by the seller's willingness to sell and the consumer's willingness to pay. The dark sky at a national park, however, is not a market good "for sale" and does not have a price tag attached to it. Economists employ two broad categories of approaches to value nonmarket goods, such as environmental quality and outdoor recreation: revealed preference (RP) and stated preference (SP) methods. In RP (also termed indirect) methods, economists examine the choices that consumers make about spending on market goods that are related to the nonmarket good(s) in question. In SP (also termed direct) methods, economists directly ask consumers of nonmarket goods to provide information that may be used to assess the value those consumers place on the consumption of the good. Most commonly, SP approaches involve asking consumers to directly state how much they would be willing to pay to enjoy more of a good (like outdoor recreation, clean air, or light-free night sky viewing) or avoid more of a bad (like air pollution or litter). However, it is also possible to ask consumers how they believe they would change their consumption of, or behavior related to, the nonmarket good in the event its quality were to either increase or decrease in the future. As explained below, this approach is attractive because it is subject to less survey response bias.

In our assessment of the importance of dark sky tourism at the park, we designed a research methodology that leverages and combines techniques from both of these broad categories of approaches. First, we employed one of the two main types of models used in RP approaches: a travel cost model (TCM). Put simply, a TCM quantitatively estimates a demand curve for outdoor recreation (a nonmarket good whose demand is influenced by, among other factors, environmental quality) and is supported by the collection of data on the volume of trips that consumers take and the round-trip cost of getting to and from the recreation site.

Second, our assessment employs a method of SP valuation known as the contingent behavior method (CBM). In the CBM, respondents to a survey are presented with a potential scenario that entails a state of the world (in our case, the nature of the night sky at the park) that differs from the current situation. Respondents are then prompted to describe how, if at all, they might change their behavior contingent upon the potential change in conditions (hence the term "contingent behavior"). Though economists historically have used the CBM much less than the contingent valuation method (CVM), in which respondents are asked to report directly their willingness to pay (WTP) for a change in environmental quality, the use of the CBM has increased in recent years. Part of its increased use may be attributed to desirable features of the method, two of which we discuss here.

One advantage of this approach is that CBM survey questions may lead to lower response bias than CVM survey questions. When respondents are asked how much they would be willing to pay for environmental quality (CVM), they may tend to inflate their monetary values to appear virtuous (i.e., as someone who cares about the environment) to the implementers of the survey. Other types of response bias may also be at work in CVM surveys. In contrast, it is reasonable to expect less response bias when respondents are simply asked how they might change their activities or behavior if the world were somewhat different from its current condition. A desirable property of the CBM relates to its ability to tap into consumers' attitudes toward and potential responses to environmental conditions that may lie well outside their historical experiences.

In our study, we combine RP data with SP data. The RP data are derived from responses to a question in our survey in which we asked respondents how many trips they have taken to the park in the past five years. This "actual trips" data indicates the revealed preferences of visitors in terms of how often they have visited in the past. At the same time, we also asked visitors if they thought they would change their trip-taking behavior in the future if the night sky at the park were to more closely resemble the way the night sky looks where they live. Specifically, the "contingent behavior scenario" was presented in our survey as follows:

> **6a**. Specifically, if the night sky at *the Great Sand Dunes* looked identical to the sky at your home base *(where you live for most of the year)*, that is, you could see about the same amount of stars here as at your home base, do you think you would change your visiting plans *(that is, either the number of visits or the length of those visits)* to *the Great Sand Dunes* over the next 5 years? *Assume that, even if we had more or fewer stars to see at night at the Great Sand Dunes, the nature of the other amenities and qualities of the Great Sand Dunes would stay the same.*

If a respondent replied "Yes" to the contingent behavior scenario, they were asked to provide details regarding how they thought they would change their future behavior (e.g., how many fewer trips, the degree to which trips in the future might be a different duration, etc.). These types of questions comprise the heart of a CB survey.

In addition to actual past and contingent future trip-taking behavior, our survey asked a number of other questions to support our analyses. This included a question about the location of the visitor's home base (residence) and questions about expenses both during travel to and from the site and during visitors' time spent in the area. Our survey also included questions about demographics (e.g., age, education, occupation, and income), whether the visitor had spent time looking at the night sky at the sand dunes, and the visitor's impressions of the quality of the night sky and stars there. These types of questions allow various analyses to characterize visitors' attitudes, backgrounds, expenses, and tourism behavior.

We collected our data by means of a hardcopy visitor intercept survey. Visitors were intercepted at two locations within the park: 1) the approach paths from the Visitor Center parking lot to the Visitor Center, and 2) the primary (largest) parking lot that feeds the main access points to the dunes. The survey was implemented over three days: October 20-22, 2023. Visitors were

intercepted, provided with a brief background on the survey, and assisted with survey completion by five students, three from Colorado College and two from the University of Northern Colorado. The project team collected 367 completed surveys from visitor-parties at the park, each corresponding to a visitor-party comprising one or more individuals.

Visitor Responses to Night Light at the Great Sand Dunes

Before asking visitors about their potential responses to changes in the night sky, it was essential to collect information on their historical trip-taking behavior. According to our survey data, visitors took an average of 1.91 trips to the park in the last five years, spending 1.58 days at the park per trip. This results in an average of 2.68 visitation days per person over the last five-year period.[1]

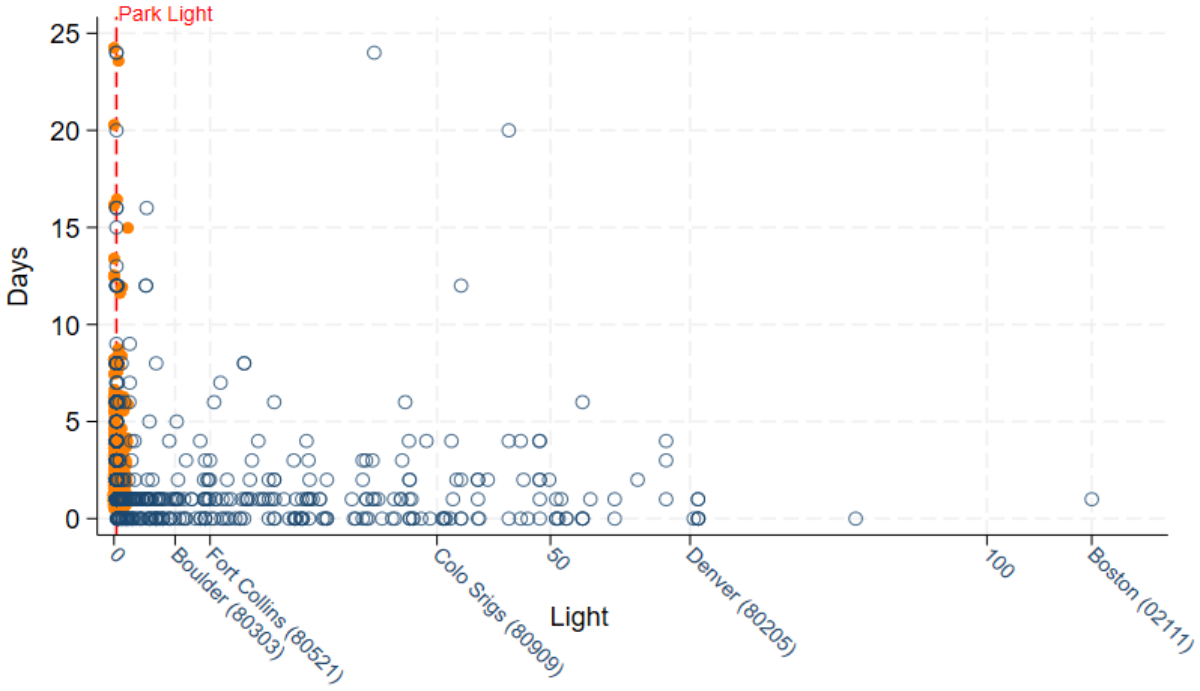
Next, we asked tourists if they would take fewer trips and/or stay for fewer days per trip in the next five years if the night sky at the park were to look the same as it does at their home while all amenities and other qualities of the park stayed the same. In response, 47% of the respondents indicated that they would spend fewer days at or take fewer trips to the park in the next five years. The average visitation days per person over the next five years dropped to 1.60 days in this hypothetical scenario.

In Figure 1, we compare the respondents' reported total visitation days per person over the next five years if the night sky were to become lighter. The red line near the origin indicates the current magnitude of light at the park, a value of 0.28.[2] If the sky resembled Fort Collins (80521), tourists reported that they would spend 0.81 fewer days on average at the park in the next five years. If it resembled Denver (80205), tourists reported that they would spend 1.51 fewer days on average at the park in the next five years.

[1] From 367 responses, we remove the ones that do not provide an identifiable home location or days of presence at the park. This leaves us 359 valid responses. We further remove two respondents that visited the park over 60 days over the last five years. This leaves us 357 visitor-parties.

[2] The data are produced by The Earth Observation Group, specifically the nighttime Visible Infrared Imaging Radiometer Suite (VIIRS) data. It is measured as the average monthly cloudless night lights captured by VIIRS satellite in 2022. The higher the number, the more lights captured by the satellite (Elvidge et al., 2013).

Figure 1: Night Light vs Visitation Days



The orange dots indicate the number of days tourists visited the Great Sand Dunes in the last five years. The navy dots indicate the counterfactual, the number of days visitors would visit over the next 5 years if the park got brighter at night, all else equal.

Who Are the Visitors?

Figure 2 below gives us a demographic breakdown of the visitors we surveyed. Approximately 49% of visitors are between the ages of 25 and 44. Over 83% of visitors have at least a college degree. Excluding retirees, students, and full-time homemakers, most visitors work in professional (Finance, Real Estate, Information, and Professional Services) and public service (Educational, Health, and Social Services) occupations. Over 50% of visitors come from suburban areas, and 27% are from urban areas. Fifty-three percent of respondents visit from within Colorado. Among the 47% from out-of-state, 18 respondents (5% of the total sample) are from another country, and 5 are from Alaska or Hawaii. About 44% of respondents reported it was their first time at the park and have not yet seen the night sky in the park area.

Figure 2. Demographic characteristics of visitors.

Category	% of Valid Responses
Age	
16-24	11.00
25-34	27.16
35-44	21.87
45-54	12.81
55-64	11.98
65+	15.18
Education	
High school or less	8.65
Some college/associate degree	8.07
College degree	46.11
Graduate degree	37.18
Occupation	
Primary and Industrial Services	5.92
Trade, Transportation, Retail, and Admin Services	8.68
Finance, Real Estate, Information, and Professional Services	50.10
Educational, Health, and Social Services	22.29
Arts, Entertainment, Recreation, Public and Other Services	13.02
Homebase	
Urban	26.61
Suburban	53.36
Rural	20.03
Homebase is in Colorado	
Yes	52.92
No	47.08
First time visiting Great Sand Dunes	
Yes	43.87
No	56.13
Have seen night sky at Great Sand Dunes	
Yes	56.06
No	43.94

How Much Do Visitors *Value* the Great Sand Dunes?

We can estimate how visitors value their visits to the park by analyzing their spending towards their trips. In our survey, we asked visitors how much they spent on roundtrip transportation from their home base to the park and how much they spent locally while in the park area. We use three measures to calculate the "value" of the park, and summarize our results in Table 1. Each measure provides a different insight, suggesting the local and broader economic benefit of tourism to the park.

We calculate the ***average reported total spending*** as the dollar amount each visitor spends per day, averaging both their transportation and local spending over the travel days and local days at the park. This value suggests the monetary contribution of each tourist to the entire economy for each day of their trip. On average, each visitor spends $83.20 per day of their trip to the park in the last five years. Older and more educated visitors tend to spend more on their trips. Visitors from out-of-state also spend more on their trips. First-time visitors, however, tend to spend less on their trips.

We calculate the ***average reported local spending*** as the per-person-per-day spending while at the park. This value suggests the tourism revenue each visitor generates in the local area, primarily in Alamosa County, for each day of their visit. On average, each visitor spends $80.44 per day while at the park. Similar to *average reported total spending,* older and more educated visitors generally spend more locally, as do visitors from out-of-state. First-time visitors spend less per day locally than repeated visitors.

Lastly, we estimate the ***average net consumer benefit*** that the park creates for the consumer (visitor). A consumer's valuation of each day at the park is largely unrecorded. For most visitors, the happiness, recreation benefits and value of spending each day at the park are much larger than the entrance fee. This is because outdoor public recreation is a classic example of a "nonmarket good." To quantify the benefit and value of such a nonmarket good, economists consider that a visitor "buys" a day at the park by spending money on the roundtrip travel cost to and from the site. Given a visitor's benefit and value derived from visiting the park each day, the visitor may not visit the park if the travel cost is overly high. If the travel cost is low, the visitor may take frequent short trips to the park. With this intuition and a sufficient number of respondents, we can express the happiness, benefit, and value derived from a tourist's visit to the park as a monetary value.

Through such methods, we estimate that a visitor derives between $323.95 and $1226.29 in net benefits from spending a day visiting the park.[3] It is termed net benefits because it represents

[3] As described above, this value is calculated from our development and application of a travel cost model (TCM), which estimates quantitatively the demand curve for recreation. The specific form of our model is a latent class negative binomial (LCNB) regression model, controlling for visitor age, their home base feature, and estimated transportation spending. In a negative binomial model, one takes the inverse of the estimated coefficient for the travel cost variable and divides it by the average party size to obtain the average net consumer benefit per day. We report

the dollar value of the benefits the consumer (visitor) derives from the recreational experience over and above the roundtrip travel costs of getting to and from the site. As critics of the first two measures might argue, the value a national park generates may exceed the GDP it creates for the local or broader area. The net consumer benefit measure copes with this criticism and shows that, for the Great Sand Dunes National Park and Preserve, tourists gain between four to fifteen times more happiness, benefit, and value than their average daily spending.[4]

Tourism Revenue and Recreation Benefits from Night Sky Conservation

Using the results of our TCM, we can estimate the decreased number of days that visitors would spend at the park over the next five years if the night sky there were to become less dark than it currently is (i.e. if more night light pollution were present). For example, as shown in the first row of Table 2, if the night light at the park increased from its current level (0.28) by a relatively small amount to the night light level of 0.76 at nearby Alamosa (zip code 81101), then an average visitor would reduce their visitation by about 0.02 days at the park over the next five years. Similarly, if the night light at the park increased by a modest amount to the night light level of 1.03 at the Colorado mountain resort town of Breckenridge (zip code 80424), then an average visitor would reduce their visitation by 0.03 to 0.04 days at the park over the next five years. In what follows, we focus on economic changes estimated to occur from increases in night light pollution to levels seen in Alamosa and Breckenridge (first two columns of Table 2).

Estimates in the table associated with night light levels in Fort Collins, Colorado Springs, and Denver provide a sense of the larger economic effects that would be expected from relatively large deteriorations in the dark sky characteristics of a site. While less likely for the Great Sand Dunes, we include them because they are instructive. Substantial increases in night light pollution may also result from potential land use and other changes in and around other sites in the U.S., including public land areas.

We can combine our survey information on visitors' average per-day local spending with our estimates of the days lost per visitor due to night light pollution. This yields the estimated loss in local spending per visitor for various increases in night light. For example, if the night light at the park were to increase to the level of Alamosa (zip code 81101), then the local area would incur a tourism revenue loss between $0.35 and $0.38 on average per visitor per year (Row 2, Table

an unweighted LCNB model that generates a lower average consumer benefit ($323.95) and a weighted LCNB model that generates a higher value of $2,226.29. The difference between the two model results is because visitors gain a large value from visiting the park, but the additional value of spending each extra day decreases as the visitor spends more days. The weighted LCNB adjusts our estimates toward the majority of visitors that spend only a day in the park and who, therefore, have a higher value per day. The unweighted results lean towards, and thus better reflect, the relatively fewer visitors who visit the park frequently, stay for longer, and display a lower value for each additional recreation day.

[4] The regression estimation requires large sample size to extract meaningful inference. Therefore, we do not report the estimation on subsamples.

2). If the night light at the park were to increase to the level of Breckenridge (zip code 80424), then the area would incur a tourism revenue decline between $0.54 and $0.59 on average per visitor per year.

Table 1. Average total spending, local spending, and net consumer benefit per day for Great Sand Dunes visitor survey respondents.

	Average reported total spending per day	Average reported local spending per day	Average net consumer benefit per day
All	$83.20	$80.44	[$323.95, $1226.29]
Age			
16-24	$41.42	$44.91	
25-34	$79.62	$83.29	
35-44	$86.18	$73.40	
45-54	$73.02	$96.01	
55-64	$102.25	$67.59	
65+	$113.40	$108.69	
Education			
High school or less	$53.21	$61.57	
Some college/associate degree	$68.43	$84.11	
College degree	$84.83	$75.82	
Graduate degree	$86.15	$86.38	
Occupation			
Primary and Industrial Services	$46.84	$75.63	
Trade, Transportation, Retail, and Admin Services	$68.09	$61.94	
Finance, Real Estate, Information, and Professional Services	$69.61	$73.76	
Educational, Health, and Social Services	$99.53	$92.21	
Arts, Entertainment, Recreation, Public and Other Services	$95.58	$67.91	
Homebase			
Urban	$82.06	$100.03	
Suburban	$70.68	$78.33	
Rural	$113.50	$62.81	
Homebase is in Colorado			
Yes	$74.96	$66.80	
No	$93.78	$96.62	
First time visiting Great Sand Dunes			
Yes	$76.41	$67.60	
No	$88.73	$91.58	
Have seen night sky at Great Sand Dunes			
Yes	$74.05	$71.17	
No	$93.04	$91.85	

Using similar methods, we calculate the average loss in net consumer recreational benefits for various increases in night light pollution (Row 3). If the night light at the park were to resemble that of Alamosa (zip code 81101), then there would be an average decrease of between $1.42 and $5.81 in net consumer (visitor) benefits for each visitor per year. If the night light at the park were to change to that of Breckenridge (zip code 80424), then there would be an average decline of $2.19 to $9.00 in net consumer (visitor) benefits for each visitor per year.

Next, we scale up these per-visitor estimates by the number of visitors the park has hosted in recent years. In 2022, there were 493,428 total recreation visits to Great Sand Dunes National Park and Preserve (Flyr and Koontz, 2023, p. 29). For estimation purposes, we assume conservatively that over the next five years, the baseline average number of total recreation visits to the park would be 500,000 annually.[5] Multiplying this visitation number by local spending lost per visitor per year yields an estimate of total local spending lost per year for various scenarios of increased night light pollution at the park (Row 4). For example, if the night light at the park were to resemble that of Alamosa (zip code 81101), then we estimate a decline of between approximately $176,000 and $191,000 per year in local spending. For an increase in night light pollution to the level now seen in Breckenridge (zip code 80424), we estimate an annual reduction of $272,000 to $295,000 in local spending.

Similarly, we calculate the aggregate net consumer benefits lost per year for various increases in night light pollution (Row 5). If the night light at the park were to resemble that of Alamosa (zip code 81101), then we project a decrease of between approximately $708,000 and $2.9 million in net consumer (visitor) benefits per year. For an increase in night light pollution to the level now seen in Breckenridge (zip code 80424), we project an annual reduction in net consumer (visitor) benefits of approximately $1.1 million to $4.5 million.

It is important to recognize potential omissions, biases, and uncertainties in our estimation of prospective changes in expenditures and benefits under a brighter-sky scenario. For example, we conservatively use recent levels of visitation at the park in scaling per-visitor impacts up to yield aggregate losses in spending and benefits. This is “conservative” because visitation numbers tend to grow over time, and our contingent behavior scenario asked visitors about their likely changes in visit behavior over the next five years. Therefore, if we instead were to scale up using projections of likely higher visitation in future years, then our aggregate estimates of losses would be higher. All else equal, our method tends to lead to estimates that are biased downward or more conservative.

A related issue involves individuals who have never visited the park but might consider visiting in the future given its current dark sky condition. These same individuals might choose not to visit if the night sky were brighter. Since our survey only polls visitors to the park, it does not provide direct information on the recreation preferences of those who have never been to the

[5] The “baseline” is an important concept in environmental economics. In this context, baseline visitation means the volume of visitation that would be expected to occur in the future in the absence of the contingent scenario. In our study specifically, this refers to visitation volumes that would be expected in the event that the current dark sky conditions at the park continue into the future.

Great Sand Dunes National Park and Preserve. It is reasonable to expect that many individuals fall into these categories. However, our analysis does not include this category of potential losses. As a result, our estimates of losses in local spending and net consumer benefits tend to be more conservative.

In addition, it is important to note that the primary results described here for reduced local spending only include decreases in direct expenditures. That is, they reflect estimates from our survey results of the declines in local spending that visitors would make under brighter-sky scenarios. However, each dollar of reduced direct spending in a region has ripple effects throughout the regional economy. When a visitor spends money, it benefits the business that sells the goods or services. That business and its employees then spend a portion of that revenue on other goods and services. This chain reaction continues, resulting in a final economic impact greater than the initial change in direct visitor spending. This is known as the ripple, or multiplier, effect, where initial changes in direct expenditures lead to changes in indirect and induced expenditures.[6]

We take advantage of previous studies to infer the value of the local area economic multiplier for the Great Sand Dunes National Park and Preserve.[7] Flyr and Koontz (2023) estimate the 2022 economic contributions to local communities, states, and the nation that are generated by each U.S. national park. For the Great Sand Dunes National Park and Preserve, they report the value of total visitor spending in 2022 as $32.538 million. The contribution to local economic output in and around the Great Sand Dunes National Park and Preserve area was $35.980 million (Flyr and Koontz, 2023, p. 29). This suggests that the local economic multiplier for this area is approximately 1.10.

We combine this multiplier with our estimates of reduced direct visitor spending to generate a projection of the local economic impact of brighter-sky scenarios at the Great Sand Dunes National Park and Preserve. For example, returning to Table 2, recall that if the night light at the park were to resemble that of Alamosa (zip code 81101), then we estimate a decline of approximately $176,000 to $191,000 per year in direct local spending. If we multiply this by an estimated local economic multiplier of 1.10, then we would expect the “Alamosa brighter night sky scenario” to generate a fall of approximately $193,000 to $210,000 in annual local economic output. Similarly, suppose the night light at the park were to increase somewhat more to resemble the level of Breckenridge (zip code 80424). In that case, we estimate a decline of approximately $272,000 to $295,000 in direct visitor spending and a fall in local economic output of approximately $299,000 to $325,000 annually.

[6] Indirect spending results from revenues generated by the suppliers of services to tourism businesses such as a motel in the vicinity of the park. Induced spending is the result of revenue generated in the area from spending by employees of tourism businesses such as a motel.

[7] To estimate the total economic impacts, economists use approaches such as input-output analysis to capture the linkages between the tourism sector and the rest of the local economy. The most commonly used software and data system is IMPLAN, which relies on county, state, and national data to generate economic multipliers at various levels of spatial aggregation.

Table 2. Lost visitor days, local spending, and net consumer benefit from various night light pollution (brighter sky) scenarios.

What if night light at Sand Dunes =	Alamosa (81101) light = 0.76	Breckenridge (80424) light = 1.03	Fort Collins (80528) light = 9.90	Colorado Springs (80909) light = 37.66	Denver (80205) light = 66.90
Days lost per visitor in the next five years	[0.022, 0.024]	[0.034, 0.037]	[0.402, 0.434]	[1.257, 1.331]	[1.813, 1.893]
Equivalent local spending lost per visitor per year	[$0.35, $0.38]	[$0.54, $0.59]	[$6.47, $6.98]	[$20.22, $21.42]	[$29.17, $30.46]
Equivalent net consumer benefit lost per visitor per year	[$1.42, $5.81]	[$2.19, $9.00]	[$26.07, $106.40]	[$81.42, $326.56]	[$117.49, $464.32]
Assume 500,000 visitors per year					
Equivalent local spending lost per year	[$175,704, $190,628]	[$272,104, $295,159]	[$3,237,032, $3,489,640]	[$10,108,130, $10,710,560]	[$14,586,905, $15,228,913]
Equivalent net consumer benefit lost per year	[$707,600, $2,906,081]	[$1,095,823, $4,499,634]	[$13,036,257, $53,198,794]	[$40,707,715, $163,280,118]	[$58,744,754, $232,161,401]

Note: the two values in each cell come from the estimation from our unweighted and weighted latent class negative binomial regressions. The weighted regression leans towards the majority of the visitors who visit the park infrequently and spend around one day during the past five years, while the unweighted regression leans towards the frequent visitors or those who spend many more days at the park in the past five years.

Conclusion

The dark skies at the Great Sand Dunes National Park and Preserve enhance the natural beauty of the dunes and offer unique opportunities for cultural and educational experiences. Visitors are drawn to the exceptional stargazing conditions, which allow them to see the Milky Way in a rare and captivating way. These experiences make the park a special destination.

Our study shows that the dark skies at the park provide significant value to visitors and boost the local economy. The park's designation as a Gold Tier International Dark Sky Park highlights its importance and the efforts made to conserve its night skies. Our research suggests that any increase in light pollution there could reduce visitation, local tourism revenue, and the net benefits and satisfaction attained by recreators.

With urbanization lighting up night skies worldwide, dark sky tourism is becoming more popular. Our study does not account for this rising trend. As more people seek out places with pristine night skies, the value of such destinations will likely increase. Including this trend in future studies would likely show even greater benefits of preserving dark skies at the park.

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