Dark sky tourism: economic impacts on the Colorado Plateau Economy, USA

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Abstract

Purpose – *This paper aims to examine the economic impact from dark-sky tourism in national parks in the USA on the Colorado Plateau. The Colorado Plateau is a region encompassing parts of Arizona, Colorado, New Mexico and Utah that is known for its dark, star-filled night skies. Tourists in national parks are increasingly interested in observing this natural recreational amenity – especially considering that it is an ecological amenity that is quickly disappearing from the planet. Using a 10-year forecast of visitors to the national parks and using standard input-output modeling, it is observed that, for the first time anywhere, the value of dark skies to tourism in this area. The authors find that non-local tourists who value dark skies will spend $5.8bn over the next 10 years in the Colorado Plateau. These tourist expenditures will generate $2.4bn in higher wages and create over 10,000 additional jobs each year for the region. Furthermore, as dark skies are even more intense natural amenity in the non-summer months, they have the ability to increase visitor counts to national parks year-round and lead to a more efficient use of local community and tourism-related resources throughout the year.*

Design/methodology/approach – *Using a 10-year forecast of visitors to the national parks and using standard input-output modeling, we find that non-local tourists who value dark skies will spend $5.8bn over the next 10 years in the Colorado Plateau.*

Findings – *These tourist expenditures will generate $2.4bn in higher wages and create over 10,000 additional jobs each year for the region. Furthermore, as dark skies are even more intense natural amenity in the non-summer months, they have the ability to increase visitor counts to national parks year-round and lead to a more efficient use of local community and tourism-related resources throughout the year.*

Originality/value – *To the best of the authors' knowledge, no other study has attempted to value the environmental amenity of dark skies.*

Keywords *Ecotourism, Dark skies, Economic impact analysis, National parks, Light pollution, Colorado Plateau*

Paper type *Case study*

1. Introduction

Tourism has been an important industry for local and regional economic growth and development for many decades. Tourists bring an inflow of domestic and international monies with purchases of lodging, food, and other goods and services. This spending helps to sustain local jobs and incomes for people involved in meeting tourists needs (Sinclair, 1998; Page and Dowling, 2001). Academic literature has documented that tourism has played a major economic role in the growth and development of many areas including Eastern Europe, rural South Africa, and Taiwan (Hall, 1991; Briedenhann and Eugenia, 2004; Kim *et al.*, 2006). Over the past 30 years or so, there has been a growing movement within the tourism industry towards ecotourism. Ecotourism provides local citizens a stake in maintaining the ecological aspects of sites (Fennell and Eagles, 1990; Muloin, 1998; Carr and Mendelsohn, 2003; Weaver, 1999). Our case study shows that dark-sky ecotourism is a multi-billion dollar industry on the Colorado Plateau.

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In 2015, the US National Park Service recorded nearly 26 million visitors to the national parks contained within Arizona, Colorado, New Mexico and Utah. These 26 million visitors spent almost $1.8bn impacting the local and state economies and creating almost 27,000 jobs. The visitors to the national parks are interested in a variety of recreational activities including camping, fishing, wildlife watching, hiking and photography. A significant, and growing, number of these visitors are also interested in star gazing and are willing to pay to be able to see dark skies at night (Mitchell *et al.*, 2017).

The national parks in this four-state region provide visitors with the opportunity to experience nature and see wildlife and picturesque vistas. They also provide a rare scenic and recreational resource that most tourists cannot find at home – the nocturnal world in its wild and natural state, largely free from light pollution (LP). LP is so pervasive that over 80 per cent of the world's population and 99 per cent of the populations of Europe and the USA live under light polluted skies. Nearly 80 per cent of North Americans cannot see the Milky Way from home and approximately 40 per cent of the US population no longer has the ability to see the night sky with an eye that can truly adapt to darkness – in other words, it's as if 40 per cent of the population never experiences "nighttime" (Cinzano *et al.*, 2001, Falchi *et al.*, 2016; Gallaway *et al.*, 2010). By maintaining dark skies, these national parks are able to provide visitors with a scenic and ecological asset that is unavailable in many parts of the country. To date, we are unaware of any literature that has sought to place a dollar value, from a tourism standpoint, on the dark skies at these national parks. This case study seeks to remedy this by examining visitor spending for dark skies in national parks. Section 2 discusses LP in general, while Section 3 examines the area of study. Section 4 outlines our methodology, and Section 5 discusses results of the economic impact analysis. Section 6 sketches out some ways that local communities can leverage dark skies to increase tourism, while Section 7 draws some conclusions.

2. Understanding light pollution

LP is increasingly recognized as a serious environmental problem. LP is the artificial light at night that degrades the utility, function, biota or aesthetics of the surrounding environment. Often this is due to the presence of poorly engineered lighting. In fact, the LP within a city can create "sky glow" that can be seen from over 100 miles away.

LP first attracted academic scrutiny by astronomers (Bertiau *et al.*, 1973). Then, in recent decades, the problem has increasingly been studied by those in the natural and biological sciences. The presence of LP is known to interfere with the normal behavior of animals, especially nocturnal animals and even some flora. This interference with activities such as eating, evading predators, mating and the like, and can have an adverse effect on the health and population size of many different species (Bennie *et al.*, 2018; Cruz *et al.*, 2018; Davies and Smyth, 2018; Kim *et al.*, 2018; Underhill and Höbel, 2018; Meier *et al.*, 2015; Salmon and Witherington, 1995; Salmon *et al.*, 1995 Verheijen,1985). Artificial light at night is a radical alteration of the environment. It can have devastating impacts on ecology and aesthetics. Accordingly, economists can study the economic costs of LP in much the same way as they might study how the *Exxon Valdez* oil spill devastated commercial fishing and tourism (Shaw, 1992; Bue *et al.*, 1998).

Dark nighttime skies, especially in national parks, can help maintain existing tourism and be used as a vehicle for attracting additional tourists to an area (Cater, 2010; Fayos-Solá, Marín and Jafari, 2014; Hänel, 2016; Labuda *et al.*, 2015; Labuda *et al.*, 2016; Rodrigues *et al.*, 2015). This effect is multifaceted. By having some areas that are free of LP, tourists have a place to observe the night sky, experience a naturally dark environment, and observe a less trampled wilderness in the same way that some people travel to Yellowstone National Park to see bison and geysers. Secondly, preserving dark nighttime skies helps to protect the health and diversity of local wildlife populations which are often the primary amenity that visitors to national parks are seeking. In short, dark skies are both a necessary and

complementary characteristic to the more well-known amenity of "wildlife" that attracts visitors to national parks. Both the damage to scenic nightscapes and any related deleterious effects on wildlife will likely reduce a visitor's willingness to pay to visit areas such as national parks.

3. Understanding the Colorado Plateau

This case study examines the economic impact from dark sky tourism in the area known as the "Colorado Plateau Dark Sky Cooperative" (Colorado Plateau) which covers approximately 130,000 square miles over the aforementioned states in the Southwestern USA and is shown in Figure 1. The Colorado Plateau is home to many national parks as well as America's first Dark Sky Cooperative. Table I lists the different national parks on the Colorado Plateau as well as their size in square miles. In addition to the national parks, there are public lands administered by the state parks, the National Forest Service (USFS), and the Bureau of Land Management (BLM). The size of these public lands can be extensive. For example, more than 70 per cent of the state of Utah is under public control, while Colorado, Arizona and New Mexico are between 30 and 34 per cent public lands. Protecting these public lands has helped safeguard dark skies on the Colorado Plateau. One would expect that explicit consideration about the value of dark skies would facilitate caring for public lands and their contribution to the landscapes, wildlife and natural experiences sought out by tourists.

Because of the low population density, abundance of public lands and a generally arid climate and high elevations, the Colorado Plateau has long enjoyed a reputation for excellent night skies with spectacular views of the stars. This combination of natural and demographic conditions creates a scarce ecotourism asset with important cultural, aesthetic, historical, and recreational dimensions (Gallaway, 2010). Such high-quality views of the night sky are increasingly rare in modern, urbanized, society. For many, a dark night sky is, in its own way, as exotic of a sight as a herd of bison or a crystal-clear glacial lake.

Figure 1 The Colorado Plateau shown in pink with areas of light pollution shown in white

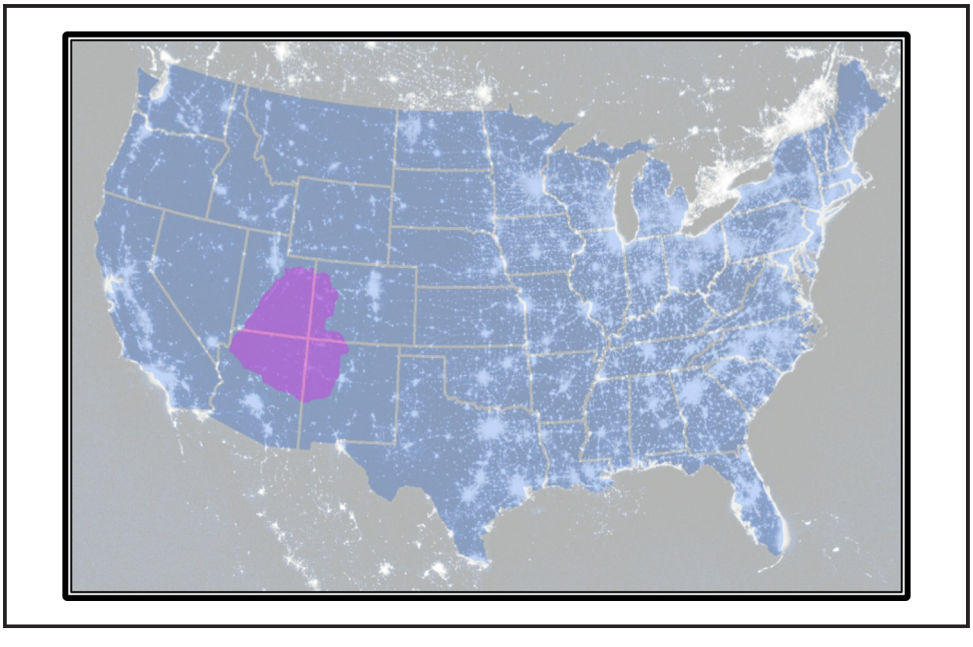


Table I NPS parks in the Colorado Plateau

National park	*State*	*Area (sq. miles)*
Arches NP	UT	120
Black Canyon of the Gunnison NP	CO	47
Bryce Canyon NP	UT	56
Canyon de Chelly NM	AZ	131
Canyonlands NP	UT	527
Capitol Reef NP	UT	378
Cedar Breaks NM	UT	10
Chaco Culture NHP	NM	53
Colorado NM	CO	32
Dinosaur NM	CO, UT	329
El Malpais NM	NM	179
El Morro NM	NM	2
Glen Canyon NRA	AZ, UT	1875
Grand Canyon NP	AZ	1902
Hovenweep NM	CO, UT	1.2
Hubbell Trading Post NHS	AZ	NA
Lake Mead NRA	AZ, NV	2338
Mesa Verde NP	CO	81
Natural Bridges NM	UT	12
Navajo NM	AZ	0.6
Grand Canyon Parashant (Meade)	AZ	1638
Petrified Forest NP	AZ	146
Rainbow Bridge NM	UT	0.25
Sunset Crater Volcano NM	AZ	5
Walnut Canyon NM	AZ	6
Wupatki NM	AZ	55
Zion NP	UT	229

International recognition of the importance of night skies on the Colorado Plateau has, in recent years, become more explicit and formalized. On March 6, 2007, Natural Bridges National Monument became the first International Dark Sky Park certified by the International Dark-Sky Association. Since then, many national parks and state parks on the Colorado Plateau have received similar recognition. This recognition is given in acknowledgement of extraordinary dark sky conservation efforts. The Colorado Plateau is unique in both the number of these Dark Sky Parks and by their superior quality; many of these parks are gold-tier certified, signifying that they have the best and rarest night skies.

The concentration of these International Dark Sky Parks on the Colorado Plateau points to the global importance of maintaining darks skies in this region. It is an immense area with skies dark enough and clear enough to make it the envy of the world. Much of the landscape is protected and even though the area is vast and remote, it is highly accessible and already a destination for millions of tourists each year. Consequently, the Colorado Plateau has a very unique and substantial potential for night sky tourism. Importantly, dark skies give tourists a reason to extend visits to include one or more overnight stays.

4. Economic impact analysis methodology

We will examine the economic impact of non-local tourists to the national parks in the Colorado Plateau who stay inside the park and consider the ability to see and enjoy night skies to be an important park amenity. We analyze the impact such tourists have on the state level economies of New Mexico, Utah, Colorado and Arizona. We estimate economic impacts of existing dark-sky oriented visitors to National Parks in the area. However, it is important to recognize that the potential for night sky tourism and its economic impact is larger. For example, we have not counted non-local visitors who value dark skies but stayed

outside of the park. Furthermore, there are good reasons to believe that there is significant growth potential for this type of ecotourism. However, the pace of this growth and the eventual magnitude of night-sky tourism depend on the willingness of stakeholders to promote night-sky tourism and leverage the region's unparalleled assets. This economic impact analysis measures existing trends, where comparatively little is done to promote night-sky tourism.

Our focus in this study is 27 parks in the Colorado Plateau administered by the National Park Service (NPS). Many of the parks are quite large, with four of them each exceeding 1,500 square miles in area. Together, these parks cover a vast area.

We used the Park Service's own data about visitation numbers and tourists' lodging choices. Economic impacts from visitor spending were analyzed using Input-Output Analysis (IO)[1]. IO is commonly used in economic research and has a long history in tourism studies (Briassoulis, 1991; Los and Steenge, 2010; Kim and Kim, 2015; Tohmo, 2018; Kronenberg *et al.*, 2018; Cline and Seidl, 2010). More specifically, we used detailed models, developed by IMPLAN[2], of the US and state level economy to analyze the economic impact of spending by overnight tourists at parks on the Colorado Plateau.

IO analysis recognizes that the impact of tourist spending gets multiplied as one person's spending creates income and more spending by others. Tourism spending creates income for hoteliers that is used to buy supplies and hire workers to meet the needs of customers; but hoteliers also have their own personal consumption spending that is entirely unrelated to the tourism industry.

The production of all goods and services requires multiple forward and backward linkages. For example, restaurants must purchase supplies of food from a wholesaler. The restaurant combines the input *eggs* with other labor and capital inputs, *cooks* and *stoves*, to provide an output, *breakfast* for customers. Raw eggs are an input for restaurants but an output for wholesalers. Input-Output analysis traces and aggregates the inter-industry linkages that exist between different goods and services. Some industries are closely related with big impacts on each other, while others have relatively few interconnections. Modeling all of these complex interconnections allows one to better understand the total impact on jobs and incomes within the region from an activity such as tourism to an area[3]. For example, Cline and Seidl (2010) showed that the economic impact from tourism related to open spaces and water quality levels were larger than the economic costs of local tax levies necessary to maintain open spaces. Thus, they argued that local tax levies that help to maintain open spaces should be implemented.

We offer similar analysis in that we are seeking to quantify the economic impact from tourism related to an environmental amenity that appeals to tourists – dark skies. To forecast the economic impact of dark skies for the next 10 years we first examine National Park Service visitation data for the past 10 years. We emphasized the spending behavior of non-local visitors. Local visitors to parks shift spending within a region rather than create new economic activity[4]. Non-local visitors were disaggregated to account for day visitors and overnight visitors. Overnight visitors were divided up into two distinct groups – those staying at the park lodges and those that were tent, Recreational Vehicle, and backcountry campers – due to differences in the amount of spending by lodge and non-lodge visitors. We also determined the compound average annual growth rate over the past 10 years in overnight and day visitors. These rates were used to project total visitors, overnight lodge visitors, and other overnight visitors for each park under study for each year for the next 10 years. As of the writing of this case study, 2015 is the most recent year for complete data not subject to future revisions.

Table II shows these growth rates as well as the number of non-local visitors by category. For example, Bryce Canyon had 1.6 million non-local visitors of which 53,792 spent the night at the park lodge and 96,694 spent the night at the park in a non-lodge format. The

Table II 2015 Visitation and 10 year compound annual growth rates (CAGR*)

Park	*Total non-local visits*	*Overnight lodge visits*	*Other overnight visits*	*CAGR* overnight lodge visits*	*CAGR* other overnight visits*
Arches	1,399,247	0	50,936	N/A	−0.32
Black Canyon	196,800	0	22,199	N/A	4.88
Bryce Canyon	1,649,360	53,792	96,694	1.82	1.73
Canyon de Chelly	762,587	6,536	607	−14.26	−32.98
Canyonlands	598,440	0	97,731	N/A	−0.05
Capitol Reef	921,558	0	43,522	N/A	2.13
Cedar Breaks	743,004	0	1,337	N/A	−1.69
Chaco Culture	37,007	0	12,987	N/A	−3.51
Colorado N M	551,344	0	19,602	N/A	3.02
Dinosaur	275,953	0	62,580	N/A	0.76
El Malpais	146,523	0	0	N/A	
El Morro	46,395	0	3,565	N/A	2.71
Glen Canyon	2,495,092	77,429	1,511,145	−5.87	4.77
Grand Canyon	5,520,736	540,000	635,342	−0.95	1.51
Hovenweep	32,980	0	2,375	N/A	5.37
Hubbell Trading Post	55,712	0	0	N/A	N/A
Lake Mead	5,063,423	21,162	461,402	−7.37	−1.57
Mesa Verde	536,320	22,019	56,407	−6.19	3.50
Natural Bridges	89,080	0	7,501	N/A	1.94
Navajo	66,964	0	3,362	N/A	0.30
Petrified Forest	742,614	0	437	N/A	4.86
Rainbow Bridge	64,907	0	0	N/A	N/A
Sunset Crater Volcano	153,050	0	0	N/A	N/A
Walnut Canyon	128,791	0	0	N/A	N/A
Wupatki	199,245	0	0	N/A	N/A
Zion	3,388,435	82,853	250,928	0.74	2.63
SUM	25,865,567	803,791	3,340,659		

Notes: Not all parks have lodges; *CAGR is the rate at which a given present value grows to a given future value in a given amount of time. CAGR = $(FV/PV)^{1/n} - 1$ where FV is the future value, PV is the present value, and *n* is the number of years

number of lodge visits to Bryce Canyon is expected to grow at an annual rate of 1.82 per cent each year for the next 10 years while non-lodge overnight visitors are expected to grow at a rate of 1.73 per cent.

Significantly, examining Table II illustrates some patterns that should be striking for those interested in the economic impact of tourism. For example, based on recent trends at Grand Canyon National Park, the number of overnight lodge visitors is expected to decline at an annual rate of 0.95 per cent while at the same time, the number of overnight non-lodge visitors can be expected to increase by 1.51 per cent per year every year. This means that by overnight lodge visitors to the Grand Canyon will decline from 540,000 in 2015 to 490,838 in 2025 – a decrease of nearly 49,161 visitors. Meanwhile, other overnight visitors will increase from 635,342 in 2015 to 758,997 in 2025 – an increase of 123,635.

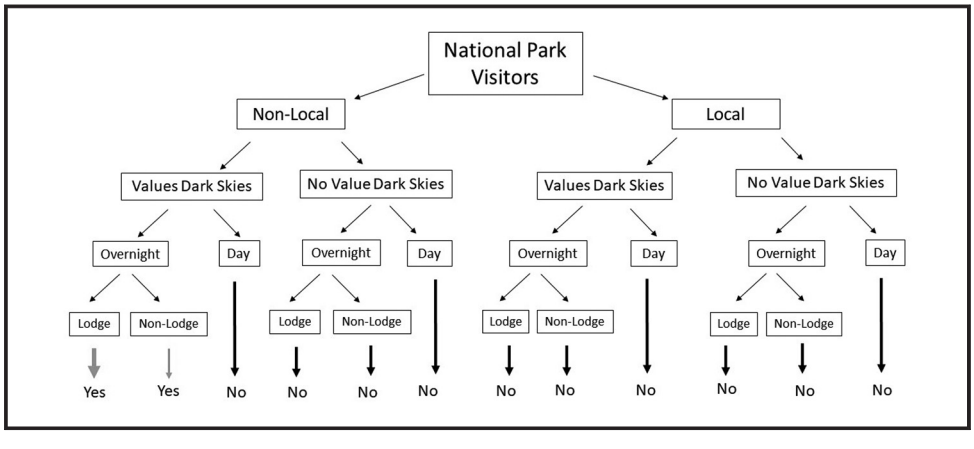
We then used National Park Service data from past studies such as park-specific expenditure surveys and other NPS sources to determine visitor spending on several different categories of goods and services (Cui *et al.*, 2013; Thomas *et al.*, 2014). These categories were retail sales, recreation spending, auto and transportation related spending, grocery spending, restaurant spending, and lodging spending. Category specific price index data for the past 10 years were collected on each of the different categories and was used to project the future prices of each of the different spending categories via the past average annual growth rate of prices within the category. Once each category's price growth rate was determined, a weighted average using each category's relative share of spending to total spending was established and used to determine the growth rate of future

spending. For example, visitors who stayed at a NPS lodge tended to spend 45.92 per cent of the total tourism dollars on lodging while those who stayed overnight in another format only spent 24.9 per cent of the tourism dollars on lodging. These group-specific spending profiles, one for overnight lodge visitors and for other overnight visitors, were adjusted for inflation so that all spending during the project time period is occurring in 2017 dollars. Finally, the spending and all economic impacts were discounted during the study period in accordance with standard economic methodology. The average yield of the 10-year US Treasury bond over the past 10 years was used as the discount rate.

Once we had the yearly number of overnight visitors by category and knew how much each visitor was going to be spending in inflation-adjusted dollars on each spending category, we needed to determine how important the dark skies were for the purpose of their visit. If a non-local visitor is spending the night at a park, but does not value a dark night sky as an attracting amenity, then it would be inaccurate to count their spending, and subsequent economic impact from that spending, in our analysis. As previously discussed, visitors who do not explicitly value dark skies might still be benefit from them if, as research suggests, dark skies help protect wildlife. Accordingly, the economic impact of preserving dark skies could be larger than the numbers presented here. Figure 2 gives a visual illustration of which visitors' expenditures are being counted in the Input-Output model. Tourists are divided into local and non-local groups which are then further subdivided into those that value dark skies and those that do not. Finally, visitors are subdivided again into overnight visitors or day visitors. Only visitors with a "Yes" are having their tourism expenditures entered into the IO model – the tourism expenditures of visitors with a "No" are left out of our IO analysis. As one can see, there is a significant amount of spending by visitors that is outside the focus of our model, which further suggests our estimate of the economic impact of dark skies on the regional economy is conservative.

Previous research has investigated the importance of scenic views and dark skies in national parks (Culesza *et al.*, 2013). Researchers conducted surveys to ascertain visitor opinions about dark night skies and other issues. In total, 41 studies were conducted between 1988 and 2011 in 15 National Parks. The surveys gathered responses from 18,345 visitor groups (Culesza *et al.*, 2013). These included several from the Colorado Plateau. Visitors were asked how important dark starry skies were to their visit. They ranked the importance on a five-tier scale from not important to extremely important. The percentage of respondents who answered that dark skies were very important or extremely important were compiled, and this weighed average of 65.1 per cent was used for parks where no dark sky opinion survey was conducted. In parks that did have data on visitor attitudes, those

Figure 2 Tourism classification illustrated



specific survey numbers were used to determine the percentage of visitors who valued dark skies.

Over the past two decades, the percentage of people who believe that dark skies are important has been increasing. For example, in 1990 only 14 per cent of visitors to Death Valley thought of dark skies as very or extremely important. By 1996, that figure had increased to 44 per cent. Similarly, when asked to rank the park asset that was the most important to protect, visitors to Death Valley rated the night sky number 8 in 1990, 7 in 1996 and 6 in 2009 (Culesza *et al.*, 2013). For the study as a whole, 2010 saw the largest number of visitors, from the most parks, surveyed. In that year, 69 per cent of respondents, on average, rated the night sky as very important or extremely important. What might be driving this increase? Perhaps people are becoming more aware of LP. Or perhaps, people are beginning to realize that dark skies are becoming "endangered" and are now more apt to act to preserve them. It should also be noted that scenic amenities have always been important to park visitors. Across the National Park Service, 90 per cent of visitors say scenic views are an extremely or very important resource to protect and preserve (Culesza *et al.*, 2013). Therefore, it seems that visitors are simply more aware that there is something worth seeing in the parks at night. No matter the reason, the conclusion is clear – dark skies and their preservation is becoming increasingly important to people. This fact suggests, once again, that the results of our study are a lower bound on the economic impact of dark skies. Growing awareness of LP as well as the creation and promotion of Dark Sky Parks suggests the percentage of visitors emphasizing the importance of dark skies will be higher, by the end of the decade, than the backwards looking average we used.

5. Economic impact results

The results of our IO analysis are shown in Table III. They show the economic impact of dark sky related tourism on the Colorado Plateau, by year, for 10 years based upon recent trends in the number of visitors, spending, and attitudes towards dark skies. This economic impact is examined under several different metrics including visitor spending, wages, value added and jobs and these are tallied in Table III for both Lodge and non-lodge overnight visitors. The data on total non-local visitor spending and the income (wages) and value added created from this spending are reported in real 2015 discounted dollars. All of the figures in the table represent the sum of direct, indirect and induced changes in the economy.

As one can see, the effect of dark skies on the state economies is quite large. In the 10 years from 2015 to 2024, visitors will spend nearly $5.75bn visiting NPS parks on the Colorado Plateau trying to see a dark sky at night. About 58 per cent of this spending will be due to NPS lodges with the remaining 42 per cent at other NPS lodging. This is despite the fact that the NPS lodges receive fewer visitors. This additional $5.75bn in spending

Table III Economic impact of dark skies total spending in 2015 (US$)

Year	*Visitor spending*	*Value added*	*Income*	*Jobs*
2015	497,643,649	331,654,954	212,717,012	8,695
2016	513,682,130	341,730,051	218,934,460	8,949
2017	513,869,262	341,559,369	218,565,144	9,224
2018	514,932,369	341,911,087	218,515,616	9,522
2019	516,855,780	342,777,292	218,780,730	9,845
2020	519,628,241	344,152,476	219,356,778	10,194
2021	523,242,484	346,033,313	220,241,354	10,570
2022	527,694,871	348,418,477	221,433,248	10,975
2023	532,985,127	351,308,507	222,932,361	11,412
2024	539,116,114	354,705,691	224,739,639	11,882
Sum	5,745,743,681	3,802,865,197	2,423,073,364	113,656

creates $3.8bn in additional value added for the local state economies. The total effect of all of this additional spending is to create an average of 10,127 additional jobs per year for a total of 113,656 future job years. This will increase wages in the states by over $2.423bn.

6. Leveraging dark-sky tourism

Table II shows a downward trend in the number of park visitors for several national parks. This is problematic for local businesses that depend upon park visitors. Recall that some parks in our study are expected to see visitorship increases – however, based on recent trends, a majority of them are projected to see decreases. Of the 20 different NPS areas that had non-lodge overnight visitors, six of them are expected to have decreases in the number of overnight visitors. The average annual decline in the number of visitors was over 6.7 per cent with a weighted average annual decline of 1.1 per cent. Some of these decreases are quite substantial. If recent trends continue, Canyon de Chelly would have annual non-Lodge overnight visitors decrease by 33 per cent every year meaning that at the end of the study period, there will only be eight non-Lodge overnight visitors to Canyon de Chelly per year. Only two of the seven lodges are projected to have increasing numbers of visitors over the next 10 years. The average annual decline in lodge visitors to the Colorado Plateau region is almost 7 per cent with a weighted average yearly decline of 1.3 per cent. The declines for lodge visitors are even more worrisome, as they have a larger economic impact on local communities then non-lodge visitors.

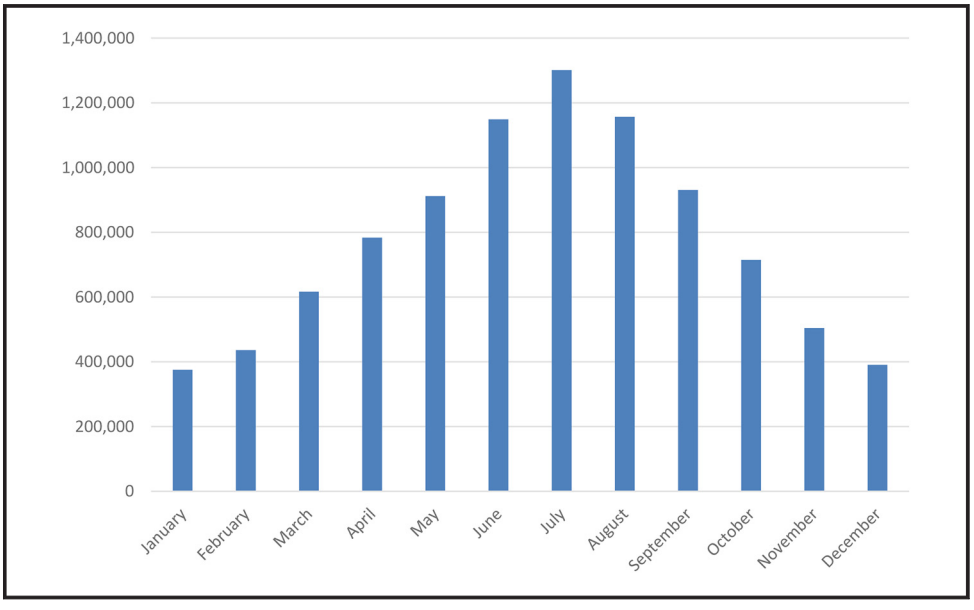
This creates a strong incentive for both the NPS parks and local businesses on the Colorado Plateau to work together to reverse recent trends, attract more visitors and increase the number of overnight stays. Survey data show that visitors are increasingly considering dark skies as an attraction and are willing to pay to see dark skies (Mitchell *et al.*, 2017). Therefore, the dark skies of the Colorado Plateau can be used, and promoted, as a magnet for tourism. Crucially, from an economic standpoint, the single most important thing about dark-sky tourism is that it necessitates one or more overnight stays. The NPS estimates that the average spending per party per day is about $90 for non-local day trips. For parties staying overnight at an NPS lodge, this spending rises to over $390, for those staying in motels outside the park, the amount is a little over $270 (Thomas *et al.*, 2014; Cui *et al.*, 2013). Increasing the number of visitors and encouraging overnight stays can have large economic benefits for the local communities.

Similarly, by focusing on dark skies as a method of attracting visitors, the parks and local communities can better use their resources without significant capital investment. Most national parks have a surge of visitors in the summer months but far fewer visitors in the other seasons as seen in Figure 3 which compiles data from Street (2014). This means the tourism related businesses and community infrastructure cannot be used in an efficient manner. Hotel rooms and restaurants vacillate between being overcrowded and empty. Dark skies grow in value as an amenity during off-peak times and can therefore be used to spur tourism during the off season leading to an increase in efficiency of tourism related infrastructure and resources.

Stargazing is, in many ways, better in the fall, winter and spring due to longer nights and other factors. For example, a popular activity among some recreational astronomers is in participating Messier Marathons, where individuals try to observe as many of the 110 deep-sky objects, such as nebulae and galaxies, cataloged by the eighteenth century astronomer Charles Messier.

Messier marathons are held near the new moons in early spring, because it is possible to see all of the objects in one night for mid to low latitudes of the Northern Hemisphere. In the Colorado Plateau, cloud free nights with good air quality are most likely to be found during May and June, as well as September and October (Moore, 2015). Accordingly, promoting dark skies will increase the number of visitors during the off-peak seasons and provide a

Figure 3 Average number of visitors per day to All NPS units by month, 2013



longer more sustained period of tourism activity providing the park and local businesses with a steadier source of income.

7. Conclusion

This case study has examined the impact that dark skies have on the local economies for areas around national parks in the Colorado Plateau. The Colorado Plateau is an area known for its dark skies. This amenity is becoming increasingly more important to visitors at the exact same time that it is becoming more threatened. Our results indicate that the current economic impact of the dark skies tourism is substantial. Of the over 4.1 million non-local overnight visitors to NPS parks on the Colorado Plateau, those who rate the night sky as very important or extremely important will, over ten years, create an additional 10,127 jobs per year on average because they will spend over $5.75bn. This will increase wages by over $2.4bn and increase gross state product by over $3.8bn.

Importantly, these numbers do not include the very substantial economic impact of the majority of non-local overnight visitors because they stayed in lodging outside the parks and were not included in our calculations. Similarly, these figures do not measure the full *economic significance* of these parks. Such a measure would include spending by locals as well. Nationally, it should be noted, spending by locals and by visitors who lodge outside of the parks account for over two-thirds of the total spending (Cui *et al.*, 2013). Additionally, these figures do not include the impact of visitors to USFS or BLM lands. For now, we do not have sufficient data to estimate the additional economic impact of night sky tourism associated with these lands. However, we do know that, on the Colorado Plateau, both of these types of lands attract tens of millions of visitors per year. We also know that experiencing nature and viewing scenic vistas are consistently important factors to many visitors to public lands. These facts speak both to the existing additional economic impact of night sky tourism in the region and to the potential for leveraging the unique resources of the Colorado Plateau to further promote such tourism.

The reported figures assume simply the continuation of existing trends, with no increase in efforts to promote night sky tourism. We have shown that dark skies are a valuable resource. This presents the local communities and the parks in the Colorado Plateau with a unique opportunity for partnership. If public land managers and local communities were to work together to promote dark sky tourism and increase the number of visitors to the area, the economic impact would be substantial. We leave this impact to future research.

Notes

1. The literature on using IO analysis, especially in economic impact studies, is vast and extensive such that the nomenclature and measurement of the different effects (direct, indirect and induced) is well understood.

   This paper is not a review of that methodology. However, for the reader who is interested, they can examine: McCann (2013), Armstrong and Taylor (2000) and Isard *et al*. (1998).

2. IMPLAN is an industry-leading software package that is used in Input-Output analysis to determine the size and nature of economic linkages using a classification system of 509 different sub-sectors of the economy.

3. When conducting economic impact analysis, different assumptions and methodologies can artificially inflate the true economic impact. For example, IO studies will often examine "total spending" on a good rather than "new spending" to inflate the economic impact estimates. They count increased spending at new attractions but not the reduced spending elsewhere. We have endeavored to act in the opposite way – taking conservative views on the data, assumptions and methodologies. Therefore, one can assume that the results from our analysis provide a lower bounds on the true economic impact of dark skies.

4. A local visitor to the park for dark skies could create new economic spending if the spending was actually new and not a rearrangement of current spending. However, we do not have data to make such judgments. Furthermore, any new local spending on gas, food and lodging would be very small.

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