Estimating the Potential Economic Value of the Night Skies Above the Colorado Plateau

by

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Summary of Economic Study:

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This study was completed through a Cooperative Agreement of the Great Rivers CESU. Authors coordinated with NRSS Social Scientists at the beginning of the study. The authors plan to publish the work in a peer-reviewed journal. If that is not done, work should be internally peer-reviewed and published as an NRSS Technical Report. Until then, work should be cited as an unpublished study or circulated only internally.

• "The complementary mutual interactions between darky-sky tourism, existing tourism, and ongoing conservations efforts are an important key to the advantages the Colorado Plateau has for dark-sky tourism. That is, one can view clear dark nights as a globally scarce, high-quality, resource that is found in abundance on the Colorado Plateau. Currently that resource is underutilized. However, exiting policies have helped to preserve it, and there is now an opportunity for a substantial increase in its utilization. A more explicit and coordinated effort to help leverage this resource could make traditional tourists more likely to visit the region and more likely to stay one or more nights." (page 13)

• In the late 2000s, 65% of visitors to Colorado Plateau parks believed that dark skies were "important" or "very important" to their visit. (page 21)

• "The effect of dark skies on the state economies [in the Colorado Plateau] is quite large. Over the next 10 years, visitors will spend nearly $2.5 Billion visiting NPS parks in the Dark Sky Cooperative trying to see a dark sky at night... This additional $2.45 billion in spending creates $1.68 billion in additional value added for the local state economies. The total effect of all of this additional spending is to create an additional 52,257 jobs that increase wages in the states by over $1,094 million dollars." (page 22)

• "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 is necessitates one or more overnight stays. The NPS estimates that the average spending per party per day is about $90 fro 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. In other words, inducing visitors to stay overnight can increase spending several fold." (page 27)

• Promoting dark skies [in the Colorado Plateau] will increase the number of visitors during the off-peak seasons and provide a longer more sustained period of tourism activity. This would provide the park and the local businesses with a steadier source of income. This also allows a more efficient use of park and local community resources." (page 34)

• We would expect the economic impact of those who rate the night sky as important or very important but who stay overnight outside the park to dwarf the $2.45 billion figure above and increase the total manifold. Importantly, these figures also do not include the impact of visitors to Forest Service or Bureau of Land Management lands." (page 35)

• "The reported figures assume simply the continuation of existing trends, with no increase in efforts to promote night sky tourism... This presents the local communities and the parks in the Colorado Plateau with a unique opportunity for partnership." (page 35)

I. *Introduction to the Colorado Plateau and the problem of light pollution*

This study examines the economic value of night skies above the Colorado Plateau. The dark nights in this area of the United States are a rare scenic and recreational resource. They provide tourists with an opportunity experience something most of them cannot find at home—a chance to see the nocturnal world in its wild and natural state, one substantially free from light pollution.

Light pollution (LP) is increasingly recognized as a serious environmental problem. Light pollution is the alteration of natural light levels in the outdoor environment by man-made sources that may degrade the utility, function, biota, or aesthetics of the surrounding environment. Often this is due to the presence of poorly engineered lighting, or an attempt to over-light an area, such as a parking lot. The light pollution within a city can create a 'sky glow' effect that can be seen from over 100 miles away.

This problem of light pollution has been studied by astronomers for many decades as the presence of light pollution interferes with their research. More recently, the problem is increasingly studied by those in the natural and biological sciences. The presence of light pollution is known to interfere with the normal behavior of animals, especially nocturnal animals, and even some fauna. This interference with activities such as eating, evading predators, mating, and the like, and is beginning to have an effect on the population size of many different animals. In this way, light pollution can be just as devastating to the local wildlife population as a chemical spill in the local watershed would be. Fortunately, many in the scientific community and the general public are beginning to recognize this and solutions to reverse or at least halt the rate of increase in light pollution are starting to take shape.

The absence of light pollution has other desirable properties in that it can be used as a method of attracting tourists to an area. 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 witness a less trammeled wilderness. Secondly, preserving dark night skies helps to protect the health and diversity of local wildlife populations that help attract tourists to a National Park in the

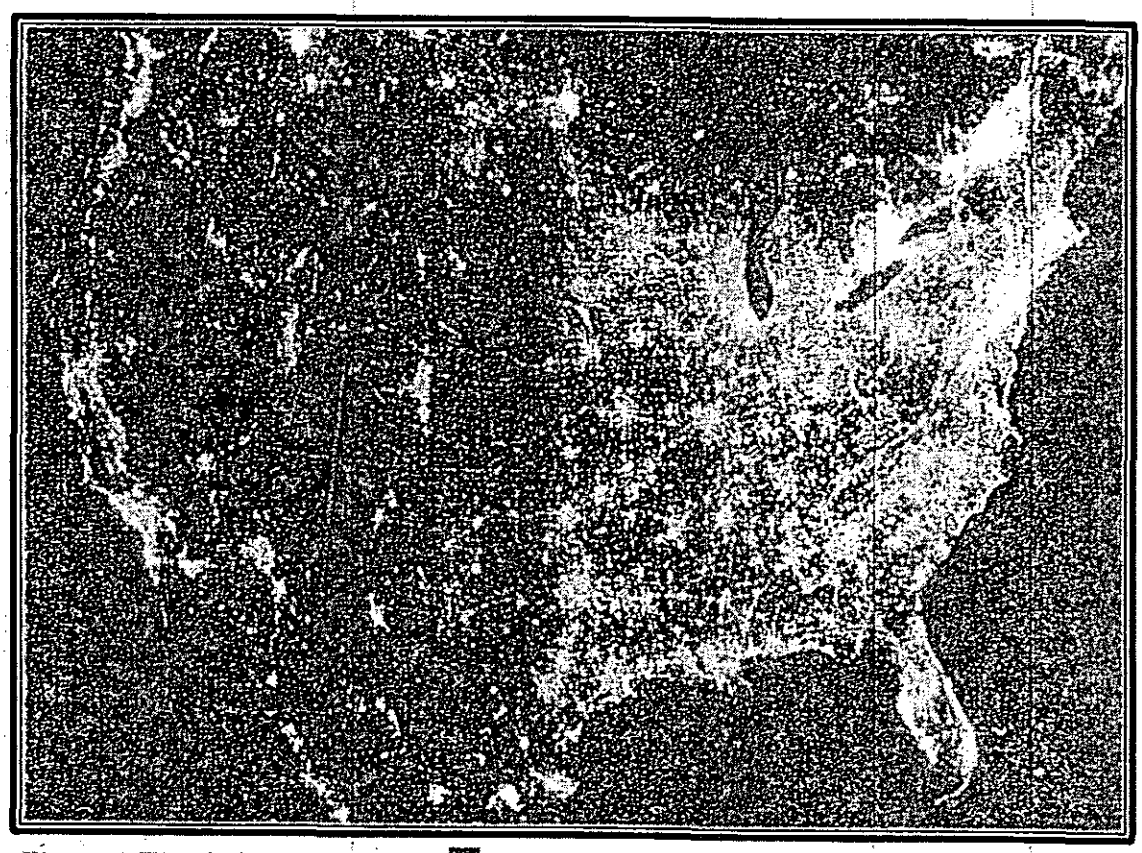


Figure 1 The Colorado Plateau

first place. The area that this report examines is the Colorado Plateau Dark Sky Cooperative which covers approximately 130,000 square miles over 4 states in the Southwestern United States: Colorado, New Mexico, Arizona, and Utah (See Figure 1). This area is home to many public lands and national parks (see Table 1). It is also home to America's first Dark Sky Cooperative. The Colorado Plateau Dark Sky Cooperative hopes to bring further recognition of the area's night skies, demonstrate tangible benefits of curtailing unnecessary outdoor lighting, reduce energy use, preserve habitat for nocturnal wildlife, and boost local economies. In addition, it hopes to preserve

the cultural benefits of the night sky by "maintaining the context of ancient cultural resources, the historic fabric and charm of small towns, and encouraging a contemporary human connection with the stars" (Department of the Interior 2012). The National Park Service has hired a full-time Colorado Plateau Dark Sky Cooperative Coordinator to work with the NPS, interested communities, businesses, individuals, and other stakeholders to support local projects and promote civic engagement with the dark skies. Protecting, recognizing, and celebrating this resource is expected to create an economic impact that is goes well beyond tourist spending.

Table 1

NPS Parks on the Colorado Plateau				
	Park Code	Park Name	State	Area (sq. miles)
1	ARCH	Arches NP	UT	120
2	BLCA	Black Canyon of the Gunnison NP	CO	47
3	BRCA	Bryce Canyon NP	UT	56
4	CACH	Canyon de Chelly NM	AZ	131
5	CANY	Canyonlands NP	UT	527
6	CARE	Capitol Reef NP	UT	378
7	CEBR	Cedar Breaks NM	UT	10
8	CHCU	Chaco Culture NHP	NM	53
9	COLM	Colorado NM	CO	32
10	DINO	Dinosaur NM	CO, UT	329
11	ELMA	El Malpais NM	NM	179
12	ELMO	El Morro NM	NM	2
13	GLCA	Glen Canyon NRA	AZ, UT	1875
14	GRCA	Grand Canyon NP	AZ	1902
15	HOVE	Hovenweep NM	CO, UT	1.2
16	HUTR	Hubbell Trading Post NHS	AZ	NA
17	LAKE	Lake Mead NRA	AZ, NV	2338
18	MEVE	Mesa Verde NP	CO	81
19	NABR	Natural Bridges NM	UT	12
20	NAVA	Navajo NM	AZ	0.6
21	PARA	Grand Canyon Parashant (Meade)*	AZ	1638
22	PEFO	Petrified Forest NP	AZ	146
23	RABR	Rainbow Bridge NM	UT	0.25
24	SUCR	Sunset Crater Volcano NM	AZ	5
25	WACA	Walnut Canyon NM	AZ	6
26	WUPA	Wupatki NM	AZ	55
27	ZION	Zion NP	UT	229

*Area treated as part of Lake Meade NRA, with no separate statistics available. The BLM manages 808,747 acres of the monument and the NPS manages 208,453 acres that were previously part of Lake Mead National Recreation Area.

For the western states of Utah, Colorado, Arizona, and New Mexico, tourism is multibillion-dollar industry. Local and non-local National Park visitors make an economic contribution to local economies in these four states of nearly $2.5 billion per year (see Table 2).

Table 2

2013 NPS Park Visitation and Local Economic Contribution

State	Total Recreation Visits	Total Visitor Spending ($ Millions)	Contribution of all Visitor Spending: Jobs	Labor Income ($ Millions)	Value Added ($ Millions)	Output ($ Millions)
Arizona	10,103,266	$773.90	11,783	$409.10	$674.50	$1,086.00
Colorado	5,393,745	$330.50	4,692	$174.80	$281.50	$460.00
New Mexico	1,512,529	$83.20	1,136	$31.60	$52.70	$93.00
Utah	8,981,447	$596.50	9,069	$287.00	$477.90	$838.30
Total	25,990,987	$1,784.10	26,680	$902.50	$1,486.60	$2,477.30

Source: Table 5, *2013 National Park Visitor Spending Effects*

This report looks at the economic impact of non-local tourists to 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 part of their travel plans. We analyze the impact such tourists have on the local economies found on the Colorado Plateau. Our methodology and data allow us to get a good sense of the impact 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 is much greater still. For example, we have not counted non-local visitors who value dark skies but stayed outside of the park. Furthermore, we will show that there are good reasons to believe that the growth potential for this type of tourism is enormous. However, the pace

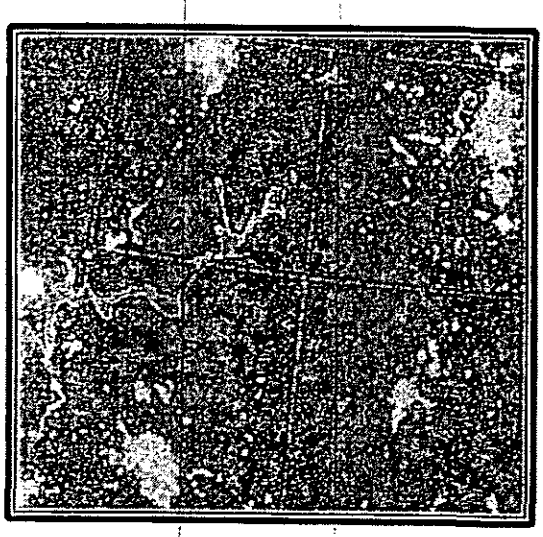


Figure 2 National Parks (Shown in [illegible]) on Thethe Colorado Plateau

Table 3: 2013 Local Economic Impact from National Parks on the Colorado Plateau

Park Unit	Total Recreation Visits	Total Visitor Spending ($000s)	Impact of Total Visitor Spending			
			Jobs	Labor Income ($000s)	Value Added ($000s)	Output ($000s)
Arches NP*	1082866	$120,171.70	1753	$46,305.80	$82,484.30	$143,260.80
Black Canyon of The Gunnison NP	165464	$10,166.90	122	$4,260.30	$6,864.90	$11,121.60
Bryce Canyon NP	1240217	$104,054.90	1422	$38,499.10	$69,258.50	$120,035.10
Canyon De Chelly NM	776737	$50,746.50	664	$15,878.50	$28,678.40	$52,196.90
Canyonlands NP	436584	$25,994.70	346	$9,302.40	$16,513.40	$28,753.80
Capitol Reef NP*	650002	$44,902.40	553	$15,136.50	$27,027.60	$47,791.50
Cedar Breaks NM	391819	$24,564.40	338	$8,836.40	$15,614.20	$27,295.50
Chaco Culture NHP	28544	$1,555.00	21	$598.80	$1,007.80	$1,755.70
Colorado NM	384019	$24,175.70	321	$8,751.60	$15,541.40	$26,808.40
Dinosaur NM	258754	$15,596.00	184	$5,660.30	$9,442.50	$15,872.70
El Malpais NM	129102	$8,263.00	119	$3,314.70	$5,643.30	$9,941.80
El Morro NM	37596	$2,354.80	32	$583.90	$1,169.30	$2,237.80
Glen Canyon NRA	1991925	$115,593.60	1435	$39,342.80	$68,821.80	$118,926.80
Grand Canyon NP*	4564841	$476,194.80	6238	$235,874.30	$399,291.60	$604,022.50
Hovenweep NM	23425	$1,469.20	19	$508.80	$889.10	$1,551.70
Hubbell Trading Post NHS	63570	$3,985.50	54	$1,257.50	$2,242.50	$4,083.40
Lake Mead NRA	4420353	$231,398.10	2628	$98,457.50	$159,141.10	$247,170.10
Mesa Verde NP*	450827	$44,973.70	616	$16,331.80	$28,654.00	$49,772.40
Natural Bridges NM	77363	$4,805.90	59	$1,607.10	$2,843.30	$4,903.40
Navajo NM	50822	$3,196.10	39	$1,071.30	$1,893.70	$3,259.50
Petrified Forest NP	603512	$38,621.30	475	$12,706.40	$22,583.00	$39,213.10
Rainbow Bridge NM	46008	$2,884.40	37	$992.70	$1,730.50	$2,978.30
Sunset Crater Volcano NM	155286	$9,735.40	123	$3,477.90	$5,916.10	$10,078.50
Walnut Canyon NM	105225	$6,596.90	83	$2,356.70	$4,008.90	$6,829.40
Wupatki NM	160338	$10,052.20	128	$3,638.00	$6,168.00	$10,489.10
Zion NP*	2617129	$144,029.90	1737	$72,163.80	$118,242.90	$183,327.80
Total	**20,912,328**	**$1,526,083.00**	**19,546**	**$646,914.90**	**$1,101,672.10**	**$1,773,677.60**

Source: Table 4, *2013 National Park Visitor Spending Effects*

of 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 in this area. That is, this economic impact analysis measures existing trends, where comparatively little is done

to promote night-sky tourism. However, local business interests could do more to leverage and promote the area's unique potential for this type of tourism. Such policy changes have the potential to dramatically increase the already large economic impact of night-sky tourism.

As mentioned above, much of the land on the Colorado plateau is public land. Our focus in this study is largely on the 27 parks in the area that are administered by the National Park Service (NPS). We focus on these parks because of the availability of data and because they already attract a great many tourists. Many of the parks are also quite large, with four of them each exceeding 1500 square miles in area (See Figure 2). Together, all of these parks cover a vast area.

In addition to National Parks, there are public lands administered by the state parks, the US Forest Service (USFS), and the Bureau of Land Management (BLM). Figure 3 superimposes Public lands on top of the earlier maps showing the Colorado Plateau. As one can see, most of the northern half, and much of the southern half of the Colorado Plateau is public land. These public lands create complementary affects when it comes to protecting dark skies on the Colorado Plateau. Protecting public lands has helped preserve dark skies in this region. Nevertheless, one would expect explicit consideration about the value of dark skies to lend additional protections to the landscapes, wildlife, and natural experiences sought out by tourists.

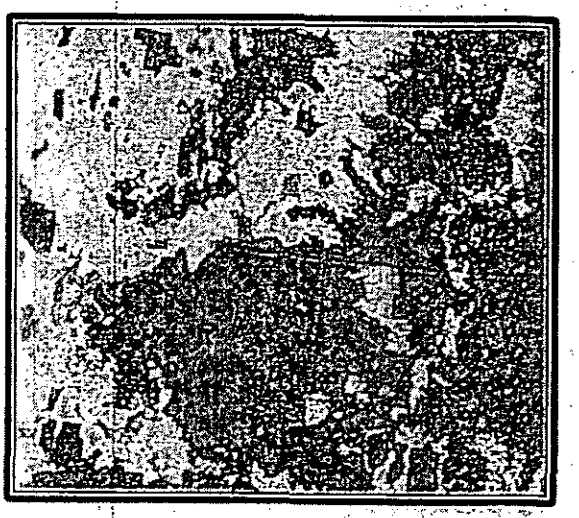


Figure 3 Public Lands On & Near the Colorado Plateau in UT, CO, AZ, NM
BLM **USFS** **NPS**

Existing Dark-Sky Recognition

The Colorado Plateau has long enjoyed a reputation for excellent night skies. Low population density and the afore-mentioned abundance public lands have helped preserve the night.

In addition, the generally arid climate and high elevation of the region lend themselves to superior views of the heavens. Consequently, nightscapes on the Colorado Plateau can be truly exquisite. They are a scarce asset with important cultural, aesthetic, historical and recreational dimensions. Such high-quality views are increasingly rare in modern, urbanized, society. People live and work in areas that are brightly lit and where 24-hour-a-day commerce is more common than unpolluted night skies. Tourists from all over the world visit the Colorado Plateau. Like most of most of the world's population, many have lost their view of the Milky Way. For them, a dark night sky is, in its own way, as exotic of a site as a heard of bison or a glacial lake.

International recognition of the importance of night skies on the Colorado Plateau has, in recent years, become more explicit and formalized. On March 6th, 2007, Natural Bridges National Monument became the first International Dark Sky Park certified by the International Dark-Sky Association. Since then, other parks on the Colorado Plateau have received similar recognition. This recognition is given in recognition of extraordinary conservation efforts. The list of International Dark Sky Parks on the Colorado Plateau now include:

- Natural Bridges NM
- Chaco Culture NHP
- Parashant International Night Sky Provence
- Hovenweep National Monument

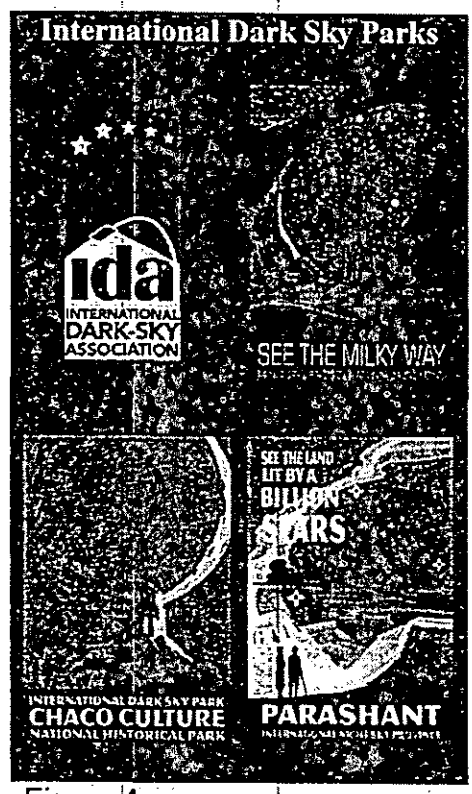


Figure 4
Sources: Dr. Tyler Nordgren, NPS, IDA

All four of these parks are gold-tier certified, signifying that they have the highest quality night skies. Together, these areas account for one quarter of all such Dark Sky Parks currently in existence worldwide.

The concentration of these International Dark Sky Parks on the Colorado Plateau points to the global importance of 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 the nightscapes have also received some level of protection, by both happenstance and concerted effort. Moreover, even though the area is vast and remote, it is highly accessible and already a destination for millions of tourists each year. For all of these reasons, the Colorado Plateau has very substantial and unique potential for night sky tourism. Significantly, the potential for increasing tourism goes far beyond just attracting visitors who are primarily interested in dark skies. The dark skies give existing and potential tourist yet another reason to come to the region. For example, the NPS Night Skies Team has started working with river guides, mountain biking trip leaders, and others to add stargazing components to their existing tours. They provide materials and a little training so commercial outfitters can feel comfortable showing the night sky to their clients. Of vital importance, dark skies also give tourist a concrete reason to extend their stays to include one or more nights. For example, "Visitors to Bryce Canyon and Cedar Breaks view parks and wilderness areas as the most preferred locations for stargazing, with 99.4% of interpretive program visitors and 79.9% of day users marking this choice" (Mace and McDaniel 2013, 52). This was true even though many visitors did not know about the night-sky related activities offered by the parks. For example, Mace and McDaniel found that, of these same visitors, "62.5% of day users and 41.8% of program visitors were unaware of existing night sky and stargazing opportunities at the parks prior to visiting" (Mace and McDaniel 2013, 52).

BLM Land and Additional Public Lands

As noted earlier, the BLM manages a great deal of land on the Colorado Plateau. In the four state area, BLM lands account for nearly thirty-one-million visitor days (see Table 4).

Table 4, Visitor Information BLM Land

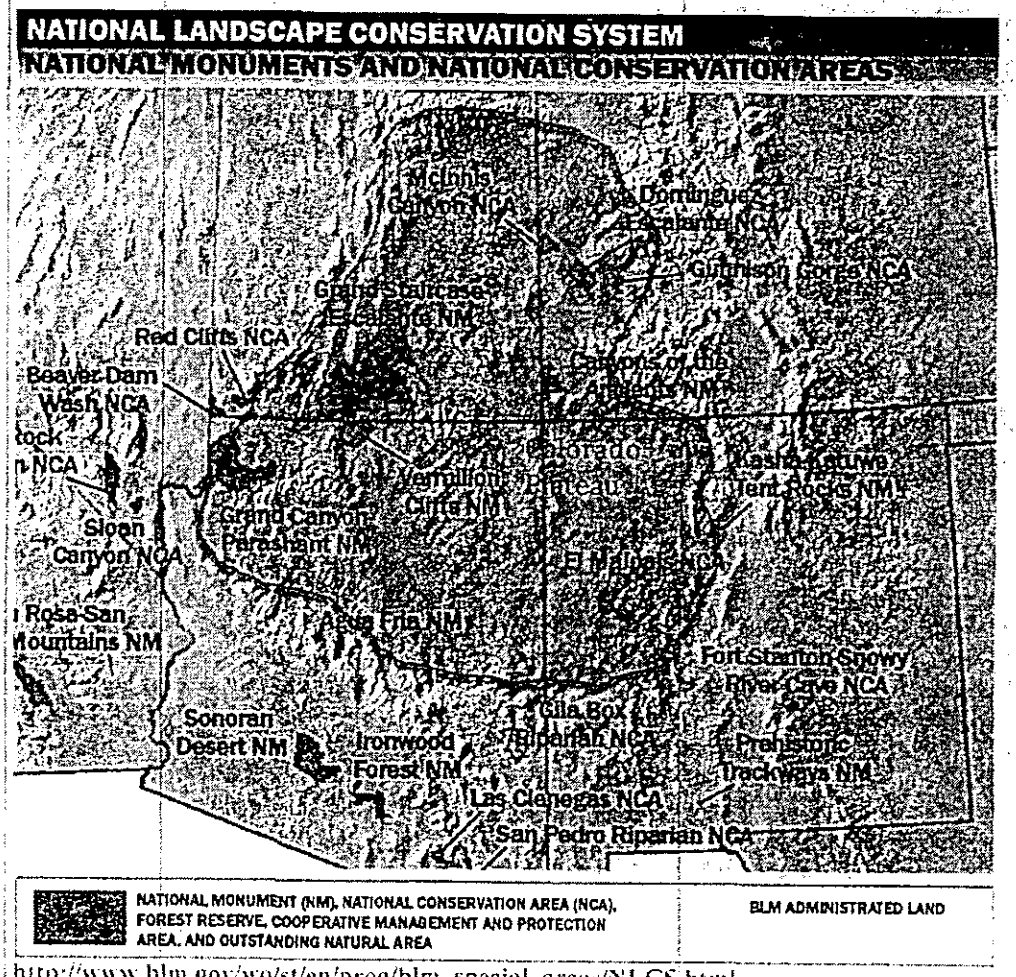
Administrative State[a]	Recreation Sites[b] Thousands		Dispersed Areas[c] Thousands		Recreation Lease Sites[d] Thousands		Recreation Partnership Sites[e] Thousands		Total Thousands	
	Visits[f]	Visitor Days[g]	Visits[f]	Visitor Days[g]	Visits[f]	Visitor Days[g]	Visits[f]	Visitor Days[g]	Visits[f]	Visitor Days[g]
Arizona	2,355	9,452	1,287	1,578	2,121	3,513	12	25	5,775	14,568
Colorado	3,308	2,059	2,957	5,395	0	0	698	128	6,963	7,582
New Mexico	1,138	579	3,442	2,867	0	0	0	7	4,580	3,453
Utah	3,259	2,137	3,517	3,100	26	10	42	78	6,844	5,325
Total	10,060	14,227	11,203	12,940	2,147	3,523	752	238	24,162	30,928

/a/ The Arizona State Office administers BLM public lands in CA along the Colorado River; the New Mexico State Office administers BLM public lands in KS, OK, and TX. /b/ These are recreation sites and other specific areas on public lands directly managed by the BLM that are recognized as "managerially significant," where managactions are required to provide specific recreation setting or activity opportunities, to protect resource values, or to enhance visitor safety. Visitation estimates are based on a variety of methods, including sampling, fee receipts, registrations, traffic counts, observations, or best estimates based on local knowledge. /c/ Dispersed areas are the remaining public lands that are open to recreational use but that do not contain developed or "managerially significant" recreation sites. Visitation estimates in dispersed areas are generally best estimates based on local knowledge. /d/ Recreation lease sites are long-term authorizations granted under the authority of the Federal Land Policy and Management Act to private entities to provide recreation facilities and services to the public. /e/ Recreation partnership sites are recreation sites managed primarily by another public entity under the authority of the Recreation and Public Purposes Act and similar agreements; the BLM has a significant presence on the leased parcel (e.g., ranger patrols, signs, brochures). /f/ A visit is the entry of any person for recreational purposes onto lands and related waters administered by the BLM, regardless of duration. /g/ A visitor day is a common unit of measure of recreational use among Federal agencies. One visitor day represents an aggregate of 12 visitor hours to a site or area.

Source: The BLM's Recreation Management Information System reports (Fiscal Year 2013).

Of particular relevance to dark-sky tourism are lands that have been especially designated for conservation. The BLM's National Landscape Conservation System, better known as the National Conservation Lands, was established in 2000 to conserve and protect nationally significant landscapes. Scenic views of wide-open spaces and wide-open skies are generally an important part of these landscapes. The conservation lands include a variety of different types of land designations such as National Monuments, National Conservation Areas, Wilderness Areas, and Wilderness

Study Areas. As once can see from Figure 5 and Table 5, there are several large examples of BLM National Monuments and Conservation Areas on or adjacent to the Colorado Plateau. Grand Canyon Parashant has already been mentioned, but the Grand Staircase-Escalante is even larger—covering 1,866,134 acres.



http://www.blm.gov/wo/st/en/prog/blm_special_areas/NLCS.html

Figure 5

Table 5, BLM Land Conservation System

BLM National Landscape Conservation System: Select National Monuments and Conservation Areas					
National Monuments					
State	National Monument	BLM Acres	Other Federal Acres	State and Private Inholdings*	Total Monument Acres
AZ	Grand Canyon-Parashant	808,747	208,453	31,125	1,017,200
AZ	Vermilion Cliffs	279,568	0	14,121	279,568
CO	Canyons of the Ancients	174,240	0	12,164	174,240
NM	Kasha-Katuwe Tent Rocks	4,124	0	1,278	4,124
NM	Rio Grande del Norte	242,555	0	0	242,555
UT	Grand Staircase-Escalante	1,866,134	0	13,977	1,866,134
National Conservation Areas					
State	Unit Name	BLM Acres	Other Federal Acres	State and Private Inholdings*	Total Unit Acres
CO	Dominguez-Escalante NCA	210,172	0	8,825	210,172
CO	Gunnison Gorge NCA	62,844	552	1,673	63,396
CO	McInnis Canyons NCA	123,430		823	123,430
NM	El Malpais NCA	230,000	0	32,960	230,000
UT	Red Cliffs NCA	44,825	0	16,385	44,825
*State and Private inholdings are not part of the BLM Unit.					
http://www.blm.gov/style/medialib/blm/wo/Law_Enforcement/nlcs/monuments.Par.37811.File.dat/Monuments_Q4_2014.pdf http://www.blm.gov/style/medialib/blm/wo/Law_Enforcement/nlcs/ncas.Par.24063.File.dat/NCAs_and_Sim_Q4_2014.pdf					

Similarly, the US Forest Service has a strong presence on the Colorado Plateau. Their visitor statistics are much less detailed than those of the NPS. Moreover, the data are aggregated by regions such that the Colorado Plateau is divided among multiple regions, each of which contains lands not on the plateau. Nevertheless, by way of example, the vast majority of NFS lands in their Rocky Mountain Region are on the Colorado Plateau. Average annual visitations for this region

between 2008 and 2012 was over 30 million visitors per year to National Forests and 1.4 million per year to wilderness areas (Department of Agriculture 2013). [1]

The Colorado Plateau contains many fine examples of wilderness areas. Wilderness areas are very special areas where landscapes and wildlife are largely undisturbed. The Wilderness Act defined these places as "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." There are a number of large and important BLM Wilderness Areas on the Colorado Plateau. These include Black Ridge Canyons, Dominguez Canyon and Powderhorn Canyon (mostly) in Colorado, and Paria Canyon-Vermillion Cliffs (mostly) in Arizona. There are, in addition, numerous US Forest Service Wilderness Areas especially in Colorado, and numerous BLM Wilderness Study Areas, especially in Utah.

These wilderness areas exemplify the pristine nightscapes that can be found on the Colorado Plateau. Moreover, it is increasingly recognized that protecting nightscapes is a vitally important to both wildlife and landscape preservation. The complementary mutual interactions between dark-sky tourism, existing tourism, and ongoing conservation efforts are an important key to the advantages the Colorado Plateau has for dark-sky tourism. That is, one can view clear dark nights as a globally scarce, high-quality, resource that is found in abundance on the Colorado Plateau. Currently that resource is underutilized. However, existing policies have helped to preserve it, and there is now an opportunity for a substantial increase in its utilization. A more explicit and coordinated effort to help leverage this resource could make traditional tourists more likely to visit the region and more likely to stay one or more nights. At the same time, one would expect such efforts would help establish a new tourism niche with its own unique needs, opportunities, and seasonal variations.

[1] By necessity, these NFS statistics are just meant to be suggestive rather than comprehensive. Some of these visits were not on the Colorado Plateau. While Colorado has a disproportionate amount of NFS land, these numbers do not include visitors in AZ, NM or UT. Accordingly, the number of NFS visitors on the Colorado Plateau as a whole would be much higher.

II. Economic Impact Analysis Methodology

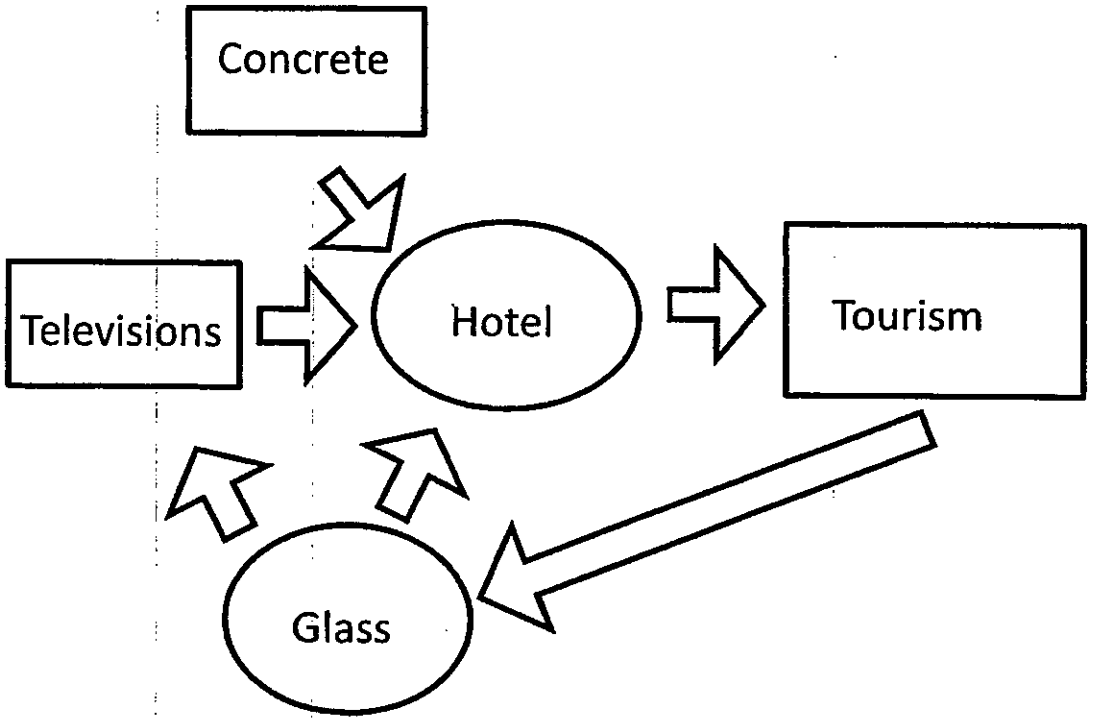
Economic impacts from visitor spending are best analyzed using Input-Output Analysis (IO) for the region in question. Input-Output analysis recognizes that in order for an output to be produced, it needs multiple inputs and the production of both the inputs and outputs have forward and backward linkages to each other. The inter-industry linkages that exist between these different industries are traced, compiled, and aggregated to better understand the forward and backward flow of economic activity within the region.

There are three distinct types of impacts when examining IO analysis. The first is direct spending and is represented by the presence of new dollars being spent within a region on the initial industry. Second, the indirect effect is the additional sales that result in the region for the industries that supply the initial industry with inputs. Finally, the induced effects result from the increased spending on all products by households in the region that now have higher income due to the increased spending in the initial industry and the supporting industries.

For example, assume that there is an increase in tourism that increases the demand for hotel rooms such that a new hotel is constructed. In order to build the hotel many inputs must be purchased including concrete, lumber, nails, televisions and furniture for the guest rooms, carpeting, and the services of carpenters, plumbers, electricians, etc. Furthermore, in order to operate the hotel, the hotelier needs to hire staff and purchase items such as office supplies, electricity, water, food, soaps, shampoos, etc. However, the production of the inputs used to produce more hotel rooms creates other inter-industry demands as well. In order to produce the extra televisions for the rooms, TV manufactures have to hire labor and procure the necessary components to manufacture televisions such as electronics, plastics, and glass. Of course, the production of glass for television screens means that glass manufacturers are faced with increased demands for their products which

necessitate their increased demand for the inputs needed to create glass. Interestingly enough, now that the glass workers are employed, their demand for vacations increases, thus increasing the demand for tourism and the industries that are associated with tourism. Figure 6 illustrates these inter-industry linkages.

Figure 6. Input-Output Analysis Illustrated



The presence of both, 1) saving behavior by people within a region, and 2) spending by people within a region on goods and services produced outside of the region leads to 'leakages' from the system. The presence of these leakages means that the subsequent rounds of additional indirect and induced spending get smaller and smaller and eventually become equal to zero.

Therefore, one is able to calculate a multiplier from the new spending in the initial industry based upon the amount of indirect and induced spending it created[2].

We wanted to estimate the economic impact of dark skies for the next 10 years; therefore, we began our study by examining National Park Service data on the number of visitors to each park in the past 10 years. Since we are interested in the economic impact of dark skies, we need to examine the spending behavior of non-local visitors. A local visitor to the parks for dark skies does not create new economic activity within a region but simply moves the economic activity between different industries within the region[3]. These 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, RV, or backcountry campers. From this we determined the compound average annual growth rate in over night and day visitors. These average annual growth rates were used to project total visitors and both classifications of overnight visitors for each park under study for each year for the next 10 years.

Examination of Table 6 shows these growth rates as well as the number of non-local visitors broken down by category. For example, Bryce Canyon had 1.1 million non-local visitors of which 48,090 spent the night at the park lodge and 89,344 spent the night at the park in a non-lodge format. The number of lodge visits to Bryce Canyon is expected to grow at an annual rate of 0.37% each year for the next 10 years while non-lodge overnight visitors are expected to grow at an average annual rate of 1.05% during the same time period.

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[2] When conducting an economic analysis impact, there are many way to alter assumptions and methodologies to artificially inflate the true economic impact. While conducting research for this project, we have acted in the opposite way—taking a more conservative view on the data, assumptions, and methodologies. Therefore, one can assume that the results from our analysis provides a ***lower bounds*** on the true economic impact of dark skies.

[3] Technically speaking, a local visitor to the park for dark skies could create new economic spending if the monies spent on dark skies represent new spending and are not simply a rearrangement of current spending. However, we did not have any data on whether local visitors coming to the parks for dark skies would be spending new dollars. Furthermore, even if local visitors were introducing new spending into the area, this amount would be very small. It is unlikely that a local visitor will spend large amounts on gas, lodging, etc.

Table 6 Visitation and 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	1,082,866		49,330		1.01
Black Canyon	165,464		18,830		2.39
Bryce Canyon	1,192,127	48090	89,344	0.374625	1.05
Canyon de Chelly	760,141	16596	527	-5.72744	-34.14
Canyonlands	436,584		86,637		-0.77
Capitol Reef	650,002		36,943		0.11
Cedar Breaks	391,819				
Chaco Culture	28,544		12,090		-4.36
Colorado N M	384,019		17,925		2.40
Dinosaur	258,754		42,922		-2.87
El Malpais	129,102		2		-43.46
El Morro	37,596		2,290		0.06
Glen Canyon	1,935,016	56909	1,375,685	-7.14484	3.19
Grand Canyon	3,972,404	592,437	426,839	0.080805	-2.39
Hovenweep	23,425		1,337		-0.94
Hubbell Trading Post	63,570				
Lake Mead	4,403,077	17276	589,630	-9.03421	-2.42
Mesa Verde	432,375	18452	35,650	-6.80972	-2.12
Natural Bridges	77,363		6,477		-0.03
Navajo	50,822		2,522		0.22
Petrified Forest	603,512		264		-1.53
Rainbow Bridge	46,008				
Sunset Crater Volcano	155,286				
Walnut Canyon	105,225				
Wupatki	160,338				
Zion	2,541,414	75,715	263,207	-0.86079	3.52
SUM	20,086,853	825,475	3,058,451		

*CAGR is the interest 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.

Significantly, examining Table 6 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 increase at an annual rate of

0.08% while at the same time, the number of overnight non-lodge visitors can be expected to decline by 2.39% per year every year. This means that by overnight lodge visitors to the Grand Canyon will grow from 592,437 in 2013 to 597,242 in 2023—an increase of only 4,805 visitors or 0.8%. Meanwhile, other overnight visitors will fall from 426,839 in 2013 to 335,134 in 2023—a decline of nearly 92,000 visitors or over 21%.

We then used National Park Service data from past studies such as the park specific expenditure surveys and other NPS sources to determine visitor spending on several different categories of goods and services[4]. 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 was 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. For example, over the past 10 years the price of auto and transportation spending has been increasing at the rate of 3.1% per year while lodging prices have been increasing at the rate of 1.5% per year. This is in comparison to the growth rate of prices in general which is 2.3%. Therefore, over the past 10 years, the prices of goods and services related to auto and transportation have been increasing faster than the rate of inflation while the price of lodging has been increasing slower than the rate of inflation. Once each category's price growth rate was determined, a weighted average using each category's relative spending share 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% of the total tourism dollars on lodging while those who stayed overnight in another format only spent 24.9% of the tourism dollars on lodging. These group specific spending profiles, one for overnight lodge

[4] Data was collected from the NPS Expenditure Surveys for Bryce Canyon, Canyon de Chelly, Capitol Reef, Glen Canyon, Grand Canyon North Rim and South Rim, Mesa Verde, Rainbow Ridge, and Zion. All other consumer expenditure data was compiled from Cui, et. al. (2011).

visitors and for other overnight visitors, were adjusted for inflation so that all spending during the project time period is occurring in 2013 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[5].

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[6]. Several of the parks have asked visitors if they thought that dark skies were important and valued. The percentage of respondents who answered that dark skies were important or very important were compiled and a weighted average based upon the number of visitors was determined for the parks that did not have survey data on visitor attitudes towards dark skies[7]. Figure 7 shows that park visitor attitudes towards dark skies are becoming more important. In 1990 there was one survey in one park whereby 14% of visitors thought that dark skies were important or

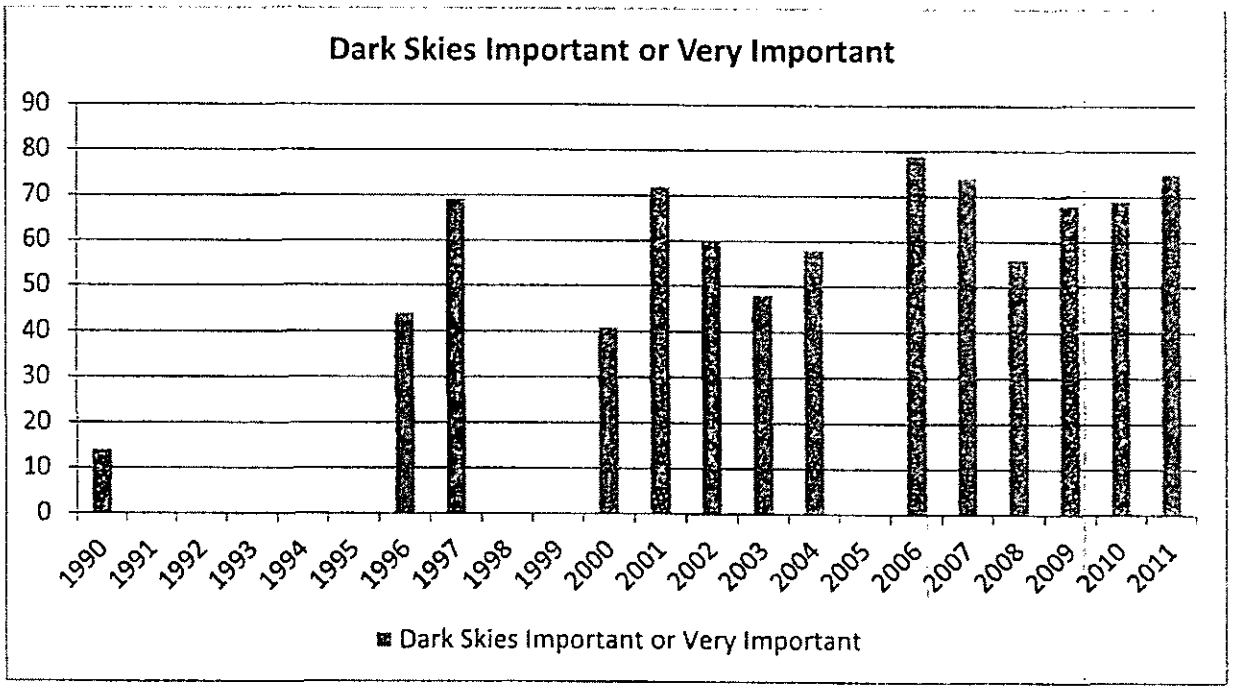
[5] Discounting is necessary in order to be able to compare flow of dollars that are occurring in different time periods. A dollar earned today is worth a dollar—but a dollar earned in 10 years is only worth 71 cents at a discount rate of 3.52%. In other words, 71 cents could be invested at a rate of 3.52% over the next 10 years and grow to be worth 1 dollar. Note that this discounting has nothing to do with inflation, but is simply a way of comparing the present value of these two flows of dollars.

[6] Importantly, visitors who do not 'value' dark skies might still be benefiting from the dark skies. It is well documented in the scientific literature that light pollution damages and diminishes local wildlife and fauna populations. Therefore, darks skies help maintain wildlife populations that attract the visitor in the first place. Without dark skies, the local wildlife population would be smaller, of less quality, or even non-existent and this change might decrease the number of future visitors. In a sense then, visitors who don't 'actively value' dark skies might 'implicitly value' dark skies since it increases the quality and quantity of the amenities that the visitors are there to see and experience. If we included the number of visitors who 'implicitly value' dark skies, the number of visitors attracted to the parks because of dark skies would increase and the economic impact would be even larger. Therefore, the reader should assume, once again, that the results in this study are a lower bounds of the true economic impact from dark skies.

[7] Assume that park A has 100,000 visitors and that 20% of them think that dark skies are important while park B has only 17,000 visitors of which 80% of them believe that dark skies are important. Park C has no data on visitor attitudes towards dark skies. To determine visitor attitudes towards dark skies in Park C, one can either use a simple average of the visitors rankings [(80+50)/2 = 65%] or a weighted percentage based upon the number of visitors with Park A's 20% receiving greater weight than Park B's 80%. In the second method, the weighted average is 28.68% [(20%)*(.854) + (80%)*(.145) = 76.07%]. We used the more conservative weighted percentage method.

very important. In 2011, a survey indicated that this number had increased to 75%. The weighted average of overnight visitors who believed that dark skies were important or very important was 65.51% and this statistic was used for park with no survey data on visitor attitudes towards dark skies. In parks that had data on visitor attitudes, those specific survey numbers were used to determine the percentage of visitors who valued dark skies.

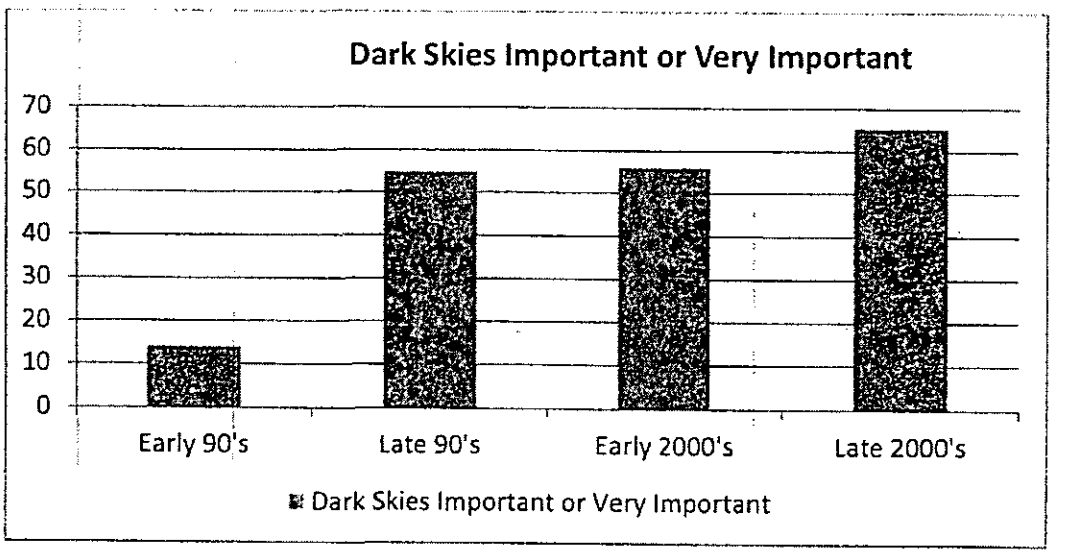
Figure 7.



It is interesting to note that over the past two decades the number of people believing that dark skies are important has been increasing. The study results shown in Figure 8 can be grouped into 4 different time periods: early 1990s, late 1990s, early 2000s, late 2000s. Taking the average of the study results in each of these different time periods produces Figure 8 which, in essence, summarizes Figure 7. The fact that visitors are seeing dark skies as something that is important is definitely increasing. Once again, note that in 1990 only 14% of visitors thought of dark skies as important whereas in the late 2000s 65% of people believe that darks skies should be preserved as

an important amenity for national parks. Of the studies in the late 2000s, the lowest reported value of survey respondents who thought that dark skies were important was 56%. What might be driving this increase in survey respondents? Perhaps people are becoming more aware and better educated about light pollution overall. Perhaps as the amount of light pollution has increased over the past 20 years, people are beginning to realize that dark skies are becoming an 'endangered species' and are now more apt to act to preserve them. No matter the reason, the conclusion is clear--Dark skies, and their preservation, are becoming increasingly more important to people[8]

Figure 8.



[8] This fact, once again, means that the results of our study are a lower bounds on the economic impact of dark skies. Recall, that this study projects economic impacts out over 10 years. In the previous 10 years, from the late 1990s to the late 2000s, the percentage of people believing that dark skies were important increased from an average of 54% to 66%. It is highly likely that 10 years into the future, at the end of our study period, the percentage of visitors believing that dark skies are important will be higher than it is today. If the current growth rate of visitors who value dark skies continues to grow at the 10 year historical rate of 1.87% per year, then 10 years into the future, fully 78% of visitors would value dark skies. This means that the actual visitor economic impact that can be attributed to dark skies would be 20% larger in 2023 than we have projected since we have used the static weighted average of 66%.

III. Economic Impact Results

Tables 7 through 10 show the current economic impact of dark skies for the states in the Colorado Dark Sky Cooperative by year for the next 10 years based upon current trends in visitorship, spending, and attitudes towards dark skies. This economic impact is examined under several different metrics including visitor spending, wages, value added, and jobs. These tables are broken down further into the two distinct categories: those that stayed at NPS lodges and those overnight visitors that stayed at the campgrounds. The fourth column tallies the two categories up for the total effect and the 10 year inflation adjusted and discounted total are tallied at the bottom of the tables. It should be noted that 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. Over the next 10 years, visitors will spend nearly $2.5 billion visiting NPS parks in the Dark Sky Cooperative trying to see a dark sky at night. About 58% of this spending will be due to NPS lodges with the remaining 42% at other NPS lodging. This is despite the fact that the NPS lodges receive fewer visitors than the campgrounds do. This additional $2.5 billion in spending creates $1.68 billion in additional value added for the local state economies. The total effect of all of this additional spending is to create an additional 52,257 jobs that increase wages in the states by over $1,094 million dollars.

Table 7. Economic Impact of Dark Skies **Total Spending** in 2013 $

	NPS Lodge	NPS Other	Total
2014	173,974,811	111,493,675	285,468,486
2015	166,192,206	109,102,504	275,294,711
2016	158,852,500	106,838,790	265,691,290
2017	151,922,374	104,695,525	256,617,898
2018	145,371,576	102,666,263	248,037,839
2019	139,172,610	100,745,020	239,917,629
2020	133,300,455	98,926,197	232,226,653
2021	127,732,316	97,204,542	224,936,858
2022	122,447,398	95,575,101	218,022,500
2023	117,426,710	94,033,201	211,459,911
Total	***1,436,392,956***	***1,021,280,818***	***2,457,673,774***

Table 8. Economic Impact of Dark Skies **Total Wages** in 2013 $

	NPS Lodge	NPS Other	Total
2014	82,193,993	44,426,940	126,620,933
2015	78,893,895	43,366,981	122,260,875
2016	75,762,090	42,363,392	118,125,482
2017	72,786,869	41,413,134	114,200,003
2018	69,957,559	40,513,388	110,470,946
2019	67,264,417	39,661,518	106,925,935
2020	64,698,544	38,855,051	103,553,596
2021	62,251,796	38,091,659	100,343,455
2022	59,916,710	37,369,144	97,285,854
2023	57,686,441	36,685,427	94,371,868
Total	***691,412,314***	***402,746,635***	***1,094,158,948***

Table 9. Economic Impact of Dark Skies **Total Value Added** in 2013 $

	NPS Lodge	NPS Other	Total
2014	123,974,842	70,838,108	194,812,949
2015	118,915,264	69,221,874	188,137,139
2016	114,120,873	67,691,803	181,812,676
2017	109,572,736	66,243,225	175,815,962
2018	105,253,622	64,871,820	170,125,442
2019	101,147,824	63,573,556	164,721,380
2020	97,241,010	62,344,654	159,585,664
2021	93,520,084	61,181,559	154,701,644
2022	89,973,070	60,080,916	150,053,986
2023	86,588,993	59,039,554	145,628,547
Total	***1,040,308,318***	***645,087,069***	***1,685,395,387***

Table 10. Economic Impact of Dark Skies **Total Jobs**

	NPS Lodge	NPS Other	Total
2014	3,530.6	1,720.2	5,250.8
2015	3,501.6	1,735.6	5,237.2
2016	3,474.4	1,752.4	5,226.8
2017	3,448.8	1,770.7	5,219.5
2018	3,424.7	1,790.4	5,215.1
2019	3,401.9	1,811.6	5,213.5
2020	3,380.5	1,834.3	5,214.8
2021	3,360.3	1,858.6	5,218.9
2022	3,341.2	1,884.5	5,225.6
2023	3,323.1	1,911.9	5,235.0
Total	***34,187.0***	***18,070.1***	***52,257.2***

IV Leveraging Dark-Sky Tourism

What is clear from the data on visitorship, is the downward trend in the number of park visitors. This is certainly problematic for both the NPS and the 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, 11 of them are expected to have decreases in the number of overnight visitors. The average annual decline in the number of visitors was over 8% which a weighted average decline of 2.3%. Some of these decreases are quite substantial. If recent trends continue, Canyon de Chelly would have annual non-Lodge overnight visitors decrease by 34% every year meaning that at the end of the study period there will only be 8 non-Lodge overnight visitors to Canyon de Chelly per year.

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 shows that visitors are increasingly considering dark skies as an attraction and are willing to pay to see dark skies. Therefore, the dark skies of the Colorado Plateau can be used, and promoted, as 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 (see figures 9 and 10). In other words, inducing visitors to stay overnight can increase spending several fold. Tables 11 through 14 show this impact. Here we see the economic impact from continuing the current visitor trends for the national parks in the Colorado Plateau with the exception of the parks that are forecasted to experience decreases in the number of visitors. We have simply assumed that visitor attendance stays static in these parks.

Figure 9.

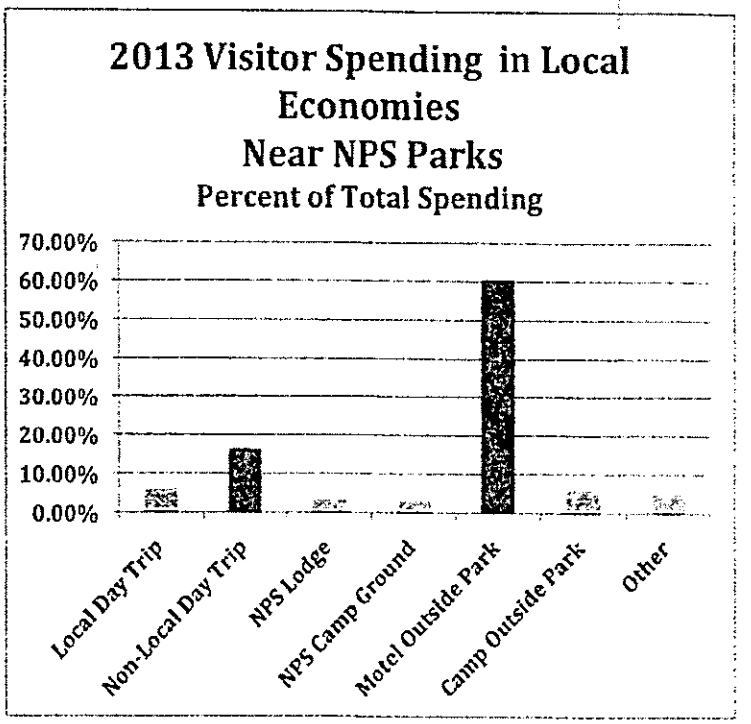


Figure 10.

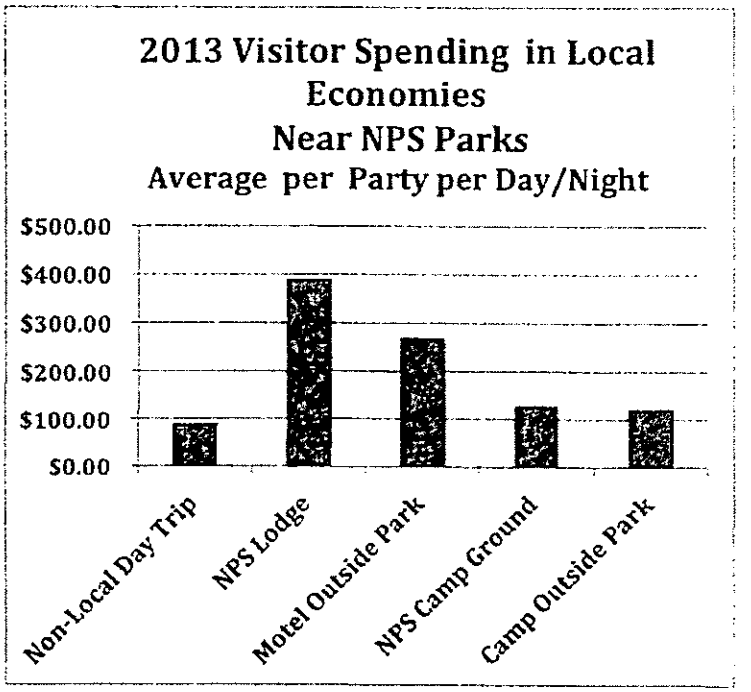


Table 11. Economic Impact of Dark Skies **Total Spending** in 2013 $ with no Decrease in Overnight Visits

	NPS Lodge	NPS Other	Total
2014	175,819,797	112,596,242	288,416,039
2015	169,628,605	111,216,642	280,845,247
2016	163,655,509	109,879,997	273,535,506
2017	157,892,823	108,585,121	266,477,944
2018	152,333,133	107,330,864	259,663,996
2019	146,969,285	106,116,107	253,085,392
2020	141,794,379	104,939,763	246,734,141
2021	136,801,756	103,800,775	240,602,531
2022	131,984,993	102,698,118	234,683,111
2023	127,337,894	101,630,794	228,968,688
Total	***1,504,218,172***	***1,068,794,423***	***2,573,012,595***

Table 12. Economic Impact of Dark Skies **Total Wages**
in 2013 $ with no Decrease in *Overnight Visits*

	NPS Lodge	NPS Other	Total
2014	82,874,100	44,919,755	127,793,855
2015	80,164,568	44,312,227	124,476,794
2016	77,543,655	43,723,459	121,267,114
2017	75,008,462	43,152,933	118,161,395
2018	72,556,184	42,600,145	115,156,329
2019	70,184,108	42,064,604	112,248,713
2020	67,889,611	41,545,835	109,435,446
2021	65,670,155	41,043,373	106,713,528
2022	63,523,284	40,556,771	104,080,054
2023	61,446,623	40,085,590	101,532,213
Total	***716,860,749***	***424,004,692***	***1,140,865,441***

Table 13. Economic Impact of Dark Skies **Total Value Added** in 2013 $ with no Decrease in Overnight Visits

	NPS Lodge	NPS Other	Total
2014	125,091,914	71,589,671	196,681,585
2015	121,001,719	70,663,339	191,665,058
2016	117,045,313	69,765,787	186,811,100
2017	113,218,317	68,896,218	182,114,535
2018	109,516,499	68,053,858	177,570,357
2019	105,935,761	67,237,956	173,173,716
2020	102,472,142	66,447,780	168,919,922
2021	99,121,810	65,682,621	164,804,431
2022	95,881,058	64,941,789	160,822,847
2023	92,746,302	64,224,613	156,970,915
Total	***1,082,030,834***	***677,503,632***	***1,759,534,465***

Table 14. Economic Impact of Dark Skies Total **Jobs**
with no Decrease in Overnight Visits

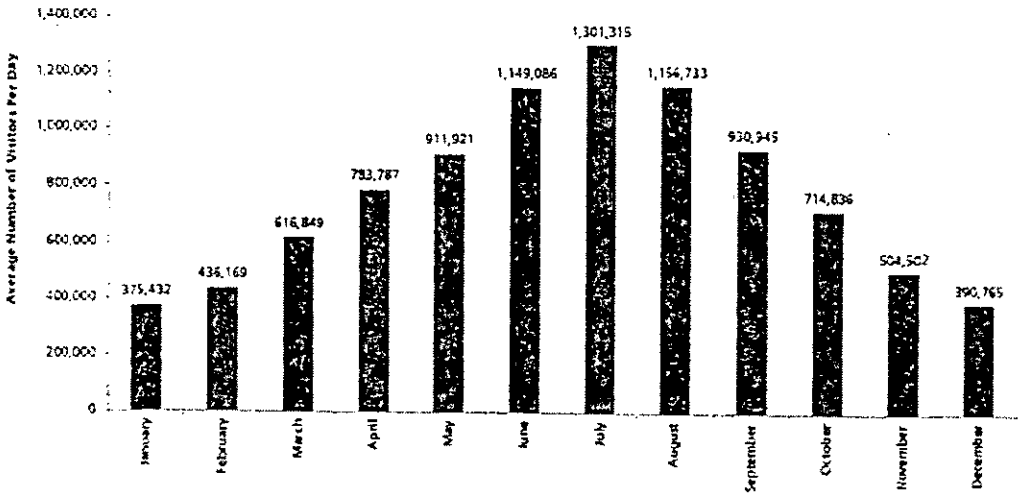
	NPS Lodge	NPS Other	Total
2014	3,557.1	1,738.3	5,295.4
2015	3,552.8	1,771.5	5,324.3
2016	3,548.4	1,805.8	5,354.2
2017	3,544.1	1,841.2	5,385.3
2018	3,539.7	1,877.8	5,417.5
2019	3,535.4	1,915.5	5,450.8
2020	3,531.0	1,954.4	5,485.4
2021	3,526.7	1,994.6	5,521.3
2022	3,522.4	2,036.1	5,558.5
2023	3,518.1	2,079.0	5,597.1
Total	***35,375.7***	***19,014.2***	***54,389.9***

As the reader will note, we can see that simply halting the decrease in visitors to certain National Parks can have a significant impact. Visitor spending increases by over $115 million with an increase in the value added created by the state economies of over $74 million. In the meantime, wages have increased by nearly $47 million and the labor market has created another 2,133 jobs. Therefore, taking steps to simply maintain the current levels of visitors can have significant economic benefits. Taking steps to increase the number of visitors, or to simply maintain the

number of visitors but to make the stay an extra night or two for the dark skies can have even larger 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 utilize their resources without significant capital investment. If there is a surge of visitors in the summer months but few, if any, visitors in the other seasons, then the park and the local businesses will experience periods of 'feast' in the summer and 'famine' in the winter (see figure 11). 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 participating Messier Marathons, where individuals try to observe as many of the 110 deep-sky objects, such as nebulae and galaxies, cataloged by the 18th century astronomer Charles Messier.

Average Number of Visitors Per Day to NPS Units by Month, 2013



Source: *Statistical Abstract 2013*, Natural Resource Data Series NPS/NRSS/EQD/NRDS

Figure 11

Messier marathons are held near the time of the new moon in late March or early April, 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 (C. Moore personal communication, March 2015). Accordingly, promoting dark skies will increase the number of visitors during the off-peak seasons and provide a longer more sustained period of tourism activity. This would provide the park and the local businesses with a steadier source of income. This also allows a more efficient use of park and local community resources. Park and local community resources, such as roads, hotels, restaurants, and other facilities, that are built to handle the summer surge in visitors but that sit mostly unused during the other seasons is an inefficient use of those resources.

V. Conclusion

This report has studied the impact that dark skies have on the local economies for areas around the 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 nearly 21 million non-local visitors to NPS parks on the Colorado Plateau, those who rate the night sky as important or very important and who stay overnight inside the park will, over the next then years, spend over $2.45 billion and create over 52,000 jobs and increases wages within the communities by nearly $1.1 billion. Furthermore, almost another $1.7 billion in value added is created within these communities.

Our focus on in-park overnight stays reflects certain data constraints as well as the fact that these are, most clearly, the visitors who can enjoy the night sky from within the park. Nevertheless, it should not be inferred that these visitors represent the largest dark-night-sky economic impact. As one can see from Figure 9, above, visitors who stay in hotels outside the park have a substantially larger economic impact than those who stay in the park. Many such visitors also value the night sky and will have the opportunity to enjoy it in the park or elsewhere. Accordingly, we

would expect the economic impact of those who rate the night sky as important or very important but who stay overnight outside the park to dwarf the $2.45 billion figure above and increase the total manyfold.

Importantly, these figures also do not include the impact of visitors to NFS 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. The parks and local communities should view the dark skies that they have as a valuable resource to be protected and leveraged in terms of local economic growth and development. 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 that issue to future research.

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