

**Characteristics, Management Preferences, and Spending
Profiles of Night Sky Recreationists in Utah**

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Table of Contents

Abstract.....	3
Introduction	4
Night Skies and Night Sky Recreation in Utah.....	4
Methods.....	5
Defining Night Sky Dependent Outdoor Recreation Activities.....	5
Data Collection.....	6
Study Population, Survey Days, Sampling Design, and Survey Administration	7
Survey Design	7
Analysis.....	8
Results	8
Survey Days and Response Rates	8
Participation in Night Sky Recreation.....	8
Place Dependence.....	10
Trip Type, Length, and Travel Distance	11
Night Sky Information and Management Preferences	12
Expenditures.....	14
Awareness and Importance of IDA Certification.....	15
Perceptions of Awe	16
Sociodemographic Characteristics	18
Discussion	19
Other Implications	21
References	22
Appendix A: Sampling Protocol.....	24
Appendix B: Survey Instrument.....	26
Appendix C: Supplementary Figures.....	37

Abstract

Night sky recreation is the pursuit of naturally dark night skies and appropriate scientific knowledge for astronomical, cultural, or environmental activities. In Utah, night sky recreation is an increasingly important part of the diverse suite of outdoor recreation activities supported by state parks as well as national parks and monuments. In this study, we collect data from a survey of evening visitors to four state parks and five National Park Service units to develop a foundational understanding of who night sky recreationists are and how they differ from other recreationists. Our findings reveal night sky dependent recreationists (individuals who observe wildlife at night, participate in night sky viewing/astronomy, or night sky photography) are a large proportion of park visitors. 61.8% of respondents indicated they participated in some type of night sky recreation activity during their visit. These visitors also tended to take significantly longer overnight trips relative to other outdoor recreationists. The analysis also revealed strong support for dark sky related management actions *from all visitors* within our sample. Between 85-90% of all respondents supported six of seven distinct types of management actions presented. Night sky dependent recreationists do support some management actions, such as setting lights to the minimum necessary brightness, moreso than other recreationists. Managers can take action to preserve and improve night sky quality and expect to receive support from the majority of visitors who use their parks/monuments at night. The analysis also revealed night sky dependent recreationists do not have significantly different spending patterns relative to other recreationists. Night sky recreation can include many activities that cost very little, if anything. As our data show, their spending behavior is no different than other recreationists for our sample. Collectively, this study provides a broad characterization of who night sky recreationists are, how they are recreating, how they would like to see night sky resources managed, and how they are spending money on their trips to Utah's parks and monuments.

Utah's Night Sky Recreationists

Introduction

Outdoor recreation plays a critical role to both Utahns' quality of life and the strength of the state's economy. Recent estimates suggest outdoor recreation accounts for over \$6 billion (2.7%) of the state's economy (Bureau of Economic Analysis, 2022). This translates into \$3.1 billion in wages and salaries for Utah workers and over 66,000 jobs (Bureau of Economic Analysis, 2022). These values are projected to increase as the state's population continues to grow and the number of out-of-state visitors continues to rise (Perlich et al., 2017).

Many public land managers and elected officials throughout the state are beginning to comprehend the importance outdoor recreation has had and will continue to have on the state's economy as well as on the economies of individual counties, cities, and towns. For example, in 2022 the Utah State Legislature set aside 1% of all sales tax collected within the state (nearly \$38 million) for the development of new outdoor recreation infrastructure (Recreation Infrastructure Amendments, 2022).

With attention slowly turning to the "industry" of outdoor recreation and its economic importance, public land managers and elected officials throughout the state need rigorous research from the social and economic sciences to provide a better understanding of outdoor recreation related spending behaviors of specific outdoor recreation activities. At the same time, characterizing the experiences of distinct types of outdoor recreationists is critical in managing destinations to meet the needs and preferences of visitors. To this end, this study evaluates and compares the management preferences and expenditures of night sky recreationists relative to other outdoor recreationists. The specific objectives of this study are to:

- Objective 1. Evaluate the differences in trip characteristics between night sky recreationists and other outdoor recreationists who visit state and National Park Service units in Utah.**
- Objective 2. Characterize and compare the night sky related management preferences of night sky recreationists with those of other outdoor recreationists.**
- Objective 3. Compare the expenditure patterns of night sky recreationists with those of other outdoor recreationists.**

Night Skies and Night Sky Recreation in Utah

Night sky recreation (or Astrotourism) is the pursuit of naturally dark night skies and appropriate scientific knowledge for astronomical, cultural, or environmental activities (Fayos-Solá & Marín, 2009). Night skies have gradually gained recognition as one of the state's most undervalued natural resources. The Utah Office of Tourism now actively markets the state's outdoor recreation destinations that have been certified as International Dark Sky Parks and Communities to out-of-state visitors (*Dark Sky Parks - Astro Tourism | Visit Utah*, n.d.). International Dark Sky Park and Community certification is earned through a rigorous 1- to 3-year application process requiring applicants such as federal or state agencies to demonstrate robust community support for dark sky protection.

Utah is a leader of dark-sky resources globally. In 2007, Natural Bridges National Monument became the world's first International Dark Sky Park. Since then, nine other national parks units within Utah earned International Dark Sky Park certification (Arches National Park, Bryce Canyon National Park, Canyonlands National Park, Capitol Reef National Park, Cedar Breaks National Monument, Dinosaur National Monument, Hovenweep National Monument, Rainbow Bridge National Monument, Timpanogos Cave National Monument, Zion National Park). Additionally, ten state parks (Antelope Island, Dead Horse Point, East Canyon, Fremont Indian, Goblin Valley, Goosenecks, Jordanelle, Kodachrome Basin, Rockport, and Steinaker) were certified. Utah is now home to 24 certified parks and communities, the highest concentration of any state in the country.

The findings of this study are valuable to a variety of stakeholders throughout Utah as well as other states looking to develop night sky recreation opportunities or rural tourism development. First, the

Utah's Night Sky Recreationists

results provide insights into the management of outdoor recreation opportunities at Utah's state parks and National Park Service units. The Utah Division of State Parks as well as the National Park Service may be able to leverage the findings of this work to acquire funding dedicated to offering interpretive programs focused on night sky recreation (e.g., astronomy, observing nocturnal wildlife, etc.) or retrofit lighting to promote better night sky viewing. These opportunities can expand the current range of outdoor recreation opportunities offered at state parks and National Park Service units and improve the quality of visitor experiences. Second, findings related to the spending behaviors of night sky recreationists can be useful to the Utah Division of Outdoor Recreation and the legislature in their deliberations and decisions about how to best provide and promote outdoor recreation opportunities within the state. Finally, results from the study can help guide the decisions of county and city governments in their tourism marketing efforts (e.g., determining whether to pursue International Dark Sky Community certification).

Collectively, by informing the decisions of outdoor recreation providers, state agencies and legislators, as well as county and city governments throughout Utah, the work may be able to expand the diversity and quality of outdoor recreation opportunities offered throughout the state.

Methods

Defining Night Sky Dependent Outdoor Recreation Activities

There is no standard definition for what activities qualify as being a night sky recreation activity. For the purposes of our analysis, we distinguish between recreationists whose activities *depend* on the night sky, and other recreationists whose activities either *involve* the night sky or have nothing to do with the night sky. Night sky dependent activities included:

- wildlife observation at night,
- night sky viewing/astronomy, and
- night sky photography.

When we refer to night sky dependent recreationists, we are referring to individuals who said they participated in at least one of the above activities. While backcountry and developed camping involve the night sky, they are not dependent upon it, so we exclude these two activities from our set of night sky dependent activities. The group against which we compare the preferences and spending behaviors of night sky dependent recreationists include any recreationist who participated in other activities besides the three night sky dependent activities listed above.

This approach to defining night sky dependent outdoor recreation activities and night sky dependent recreationists uses very clear and discrete criteria. Because it is grounded in individuals' activity choices, it is a *behavioral* approach. We contend that if an individual chooses to participate in an activity that inherently requires a dark night sky, then that person can be defined as a night sky recreationist. An analogous example would be classifying someone who hunts as a wildlife-dependent recreationist, which is done commonly in the recreation management literature¹. Some may argue that many people gaze up at the night sky, but that doesn't *really* make them a night sky recreationists. This argument points to a different way of conceptualizing and studying what a night sky dependent recreationist is, an approach grounded more in recreationists' perceptions of themselves than in their behaviors (this would be a *cognitive* approach). Future work can use our behavioral definition of night sky recreationists as a starting point, and then dig deeper into the more cognitive topics such as what it *means* to be a night sky recreationists and how dependent individuals are on naturally dark skies. Some work along these lines has already been done (Derrien & Stokowski, 2020), but more is certainly needed to better understand night sky recreationists.

¹ The term "wildlife dependent recreation" is also codified into U.S. law using a very similar approach that we adopt here (see 16 USC 668ee).

Utah's Night Sky Recreationists

Data Collection

Data were collected through an on-site survey administered to visitors at four state parks, four national parks, and one national monument within Utah. These park units are listed in Table 1 and shown in Figure 1. The ecological characteristics, geographic sizes, amount of visitation, and visitor experiences provided across these nine park units are exceptionally variable. However, all have been certified as IDA International Dark Sky Parks, a designation given to parks “possessing an exceptional or distinguished quality of starry nights and a nocturnal environment that is specifically protected for its scientific, natural, educational, cultural heritage, and/or public enjoyment” (International Dark-Sky Association, 2022).

Table 1. State and national parks surveyed.

Park Unit	2021 Reported Visitation	Certified IDA International Dark Sky Park (year of designation)
State Parks		
Antelope Island State Park	1,074,569	Yes (2017)
Fremont Indian State Park	52,423	Yes (2021)
Dead Horse Point State Park	1,265,223	Yes (2016)
Goblin Valley State Park	453,937	Yes (2016)
National Parks		
Arches National Park	1,806,865	Yes (2019)
Bryce Canyon National Park	2,104,600	Yes (2019)
Canyonlands National Park	911,594	Yes (2015)
Capitol Reef National Park	1,405,353	Yes (2015)
Natural Bridges National Monument	73,484	Yes (2007)

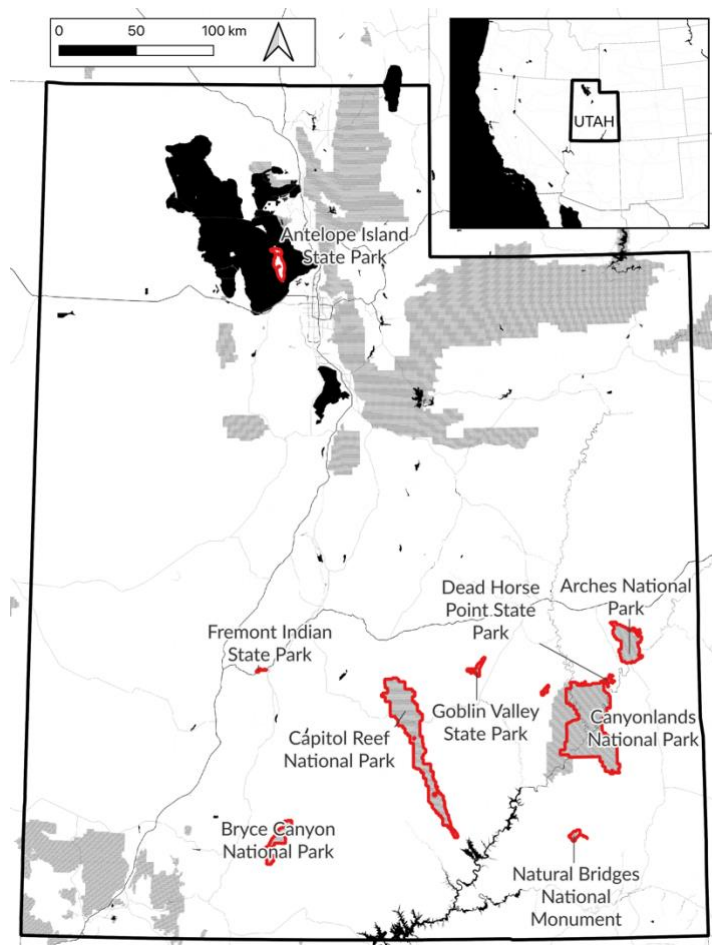


Figure 1. Map of state parks, national parks, and the national monument included in this study.

Utah's Night Sky Recreationists

Study Population, Survey Days, Sampling Design, and Survey Administration

The study population consists of individuals who recreate in state and national parks just before and after sunset. We deliberately focused on visitors within parks during this time to maximize the likelihood of contacting recreationists participating in a night sky dependent recreation activity. The results are not generalizable to all state or national park visitors.

Between April 1, 2021, and May 31, 2022, we intercepted visitors on 82 distinct site-days across the nine sampled parks/monuments. Sampling was initially planned to commence in the fall of 2020 but was delayed due to concerns about interacting with visitors during the COVID-19 pandemic. We attempted to evenly distribute site-days across state parks and national parks/monument as well as between weekdays (Monday through Friday) and weekends (Saturday and Sunday), but occasionally needed to adjust the sampling schedule due to weather and the availability of survey technicians. The full list of sampled locations is provided in Table 2; each park unit's sampling locations were identified based upon personal discussions between the research team and park staff.

We surveyed visitors from 1-hour before sunset to 2-hours after sunset. Each survey-day lasted approximately 3-hours. Sampling visitors after civil twilight allowed us to contact as many visitors as possible who were engaging in night sky dependent outdoor recreation activities (e.g., astrophotography, viewing wildlife at night, etc.).

Survey technicians contacted groups at campsites, overlooks, roadside pull-outs, and parking areas where visitors congregate. The technicians used a systematic protocol that involved sampling groups at campsites first, followed by overlooks, roadside pull-outs, and finally parking areas (the protocol is included in Appendix A). We asked only one visitor from each group, the one with the most recent birthday, to participate in the survey. At overlooks and parking areas, the survey technician stood near a bi-fold display that read "Recreation survey. Please stop." Technicians were equipped with red lights to illuminate the display and the survey site. All surveys were completed using the Qualtrics survey administration application loaded onto iPad tablet computers. The screens on all tablets were set to the minimum possible brightness to first, minimize the possibility of the survey negatively affecting visitors' night sky experience, and second, to minimize the time needed for visitors' vision to adjust when they were asked to look up at the night sky for 30-seconds at one point in the survey (just prior to responding to questions about their experience of awe).

Table 2. Sampling locations for each park unit.

Park Unit	Sampling Locations
State Parks	
Antelope Island State Park	Bridger Bay Campground (26 sites); Ladyfinger Campground (5 sites); White Rock Bay Campground (20 sites)
Fremont Indian State Park	Castle Rock Campground (31 sites); Sam Stowe Campground (7 sites + 2 cabins)
Dead Horse Point State Park	Kayenta Campground (21 sites); Wingate Campground (31 sites); Dead Horse Point Overlook
Goblin Valley State Park	Goblin Valley State Park Campground (25 sites); Observation Point
National Parks	
Arches National Park	Devils Garden Campground (51 sites); Roadside pull-offs along Arches National Park Road
Bryce Canyon National Park	North Campground (99 sites); Sunset Campground (100 sites)
Canyonlands National Park	Needles District (Squaw Flat) Campground (11 sites)
Capitol Reef National Park	Fruita Campground (71 sites)
Natural Bridges National Monument	Natural Bridges National Monument Campground (13 sites)

Survey Design

The survey instrument was constructed by the research team in close consultation with program administrators within the National Park Services' NSNSD. The instrument consisted of seven distinct sections:

1. **Trip-related characteristics:** Including park visitors' activity preferences, the duration of the trip on which they were intercepted, the size of their group, etc.

Utah's Night Sky Recreationists

2. **Night sky related information and management preferences:** Park visitors' preferences for dark sky recreation opportunities and on-site interpretation materials.
3. **Expenditures:** Park visitors' spending behavior in the local area around the park.
4. **Awareness and importance of IDA certification:** The extent to which park visitors were aware of the park's IDA certification prior to their visit, and the importance of visiting a dark sky certified park.
5. **Perceptions of awe:** Agreement with statements intended to measure the extent to which the quality of the night sky inspires the emotional response of awe.
6. **Sociodemographic characteristics:** Basic sociodemographic characteristics of park visitors.

The full survey instrument is included in Appendix B.

Analysis

We use univariate statistics to describe all data collected from both night sky dependent recreationists as well as other recreationists. Where appropriate, we also compare the responses of night sky dependent recreationists to other recreationists using comparative statistics (e.g., χ^2 and t -tests). It is worth noting that our comparative group of "other recreationists" is not representative of all state or national park visitors; it is representative of individuals who recreate in state and national parks just before and after sunset. Where appropriate, we also compare the responses of visitors to state parks with those of visitors to national parks/monuments.

Results

Survey Days and Response Rates

After ad-hoc adjustments to the schedule, we were able to collect data during 44 site-days at state parks and 38 site-days at national parks/monuments (Table 3). The total number of contacts made, completed surveys, and resulting response rates by park unit are shown in Table 3. In total, we made 776 contacts with visitors (373 at state park units and 403 at national park units) and received 634 completed surveys (290 at state park units and 344 at national park units). The overall response rate was 81.7%, which is more than acceptable for in-person surveys (Dillman et al., 2008).

Table 3. Survey periods, responses, and response rates.

Park Unit	Survey Periods	Contacts	Completed Surveys	Response Rate (%)
State Parks	44	373	290	77.7
Dead Horse Point State Park	20	189	148	78.3
Goblin Valley State Park	15	121	95	78.5
Fremont Indian State Park	4	31	27	87.1
Antelope Island State Park	5	32	20	62.5
National Parks	38	403	344	85.4
Bryce Canyon National Park	15	197	170	86.3
Canyonlands National Park	3	85	71	83.5
Arches National Park	6	73	61	83.6
Natural Bridges National Monument	5	27	25	92.6
Capitol Reef National Park	9	21	17	81.0

Participation in Night Sky Recreation

We first asked respondents which outdoor recreation activities they participated in within the park unit they were surveyed at; the proportion of respondents participating in each activity is shown in Table 4. The popularity (i.e., rank ordering) of outdoor recreation activities were similar across both state and national park units. However, national park unit visitors reported participating in significantly more activities (mean = 4.90) relative to state park visitors (mean = 4.42) ($t(628) = -3.241, p = 0.001$). Mountain biking was the only activity for which a significantly greater proportion of state park visitors participated in, relative to national park unit visitors.

Utah's Night Sky Recreationists

We classified three activities as “night sky dependent,” these include: wildlife observation at night; night sky viewing/astronomy, and night sky photography. Over half (56%) of all respondents reported they participated in night sky viewing/astronomy. Approximately 15% and 14% reported participating in night sky photography and viewing wildlife at night, respectively. Just under 62% of respondents reported participating in at least one night sky dependent outdoor recreation activity; this proportion was similar across both state parks (64.3%) and national park units (59.6%). Two percent of respondents indicated that their *primary* activity was night sky photography while 5% indicated their primary activity was night sky viewing/astronomy. No respondents indicated their primary activity was viewing wildlife at night.

We examined differences between night sky dependent recreationists and other recreationists in the activities they reported participating in (Table 4). A significantly larger proportion of night sky dependent recreationists participated in scenic driving (+ 12.8%), developed camping (+13.5%), wildlife observation during the day (+ 24.2%), and visiting historic or cultural sites (+19.4%) relative to other recreationists. Night sky dependent recreationists also reported participating in more activities (*mean* = 5.5) than other recreationists (*mean* = 3.4); the difference was significant ($t(626) = 16.34, p < 0.001$)².

We did not observe any statistically significant differences across state and national park units in the proportion of visitors participating in these night sky dependent activities (Table 4). This is likely attributable to the fact night sky dependent outdoor recreation does not require any outdoor recreation infrastructure (e.g., trails, roads, campsites, etc.) that facilitates many other activities. Quite the opposite, high-quality night sky dependent activities are often improved through a lack of infrastructure (primarily the lighting of that infrastructure) and the lack of concentration of human activity (e.g., headlights and headlamps in parking areas and attraction sites). Night sky recreation opportunities are not just offered within the boundaries of state and national parks, and it is highly likely that some notable proportion of night sky recreationists actively choose *not* to recreate in parks given that is where other recreationists congregate, and potentially diminish the quality of night sky outdoor recreation experiences they are seeking.

² The length of the trip (i.e., days) was not significantly related to the number of activities that recreationists participated in ($r = 0.234, p = 0.261$).

Utah's Night Sky Recreationists

Table 4. Proportion of respondents who participated in different recreation activities.

Recreation Activity	Total (%) (n = 630)	State Park Units (%) (n = 288)	National Park Units (%) (n = 342)	Sig. Diff. (p-value)[†]	Night Sky Dependent Recreationists (%) (n = 388)	Other Recreationists (%) (n = 240)	Sig. Diff. (p-value)[†]
Hiking	90.6	85.4	95.0	0.000	92.5	88.3	0.052
Scenic driving	81.0	75.3	85.7	0.000	86.1	73.3	0.000
Developed camping	80.2	71.9	87.1	0.000	85.6	72.1	0.000
Night sky viewing/astronomy	56.0	56.3	55.8	0.280	91.0	0.0	0.000
Wildlife observation during the day	48.1	38.9	55.8	0.000	57.5	33.3	0.000
Visiting historic or cultural sites	34.8	30.2	38.6	0.004	42.3	22.9	0.000
Mountain biking	16.7	22.9	11.4	0.002	16.5	17.1	0.465
Night sky photography	14.9	17.4	12.9	0.322	24.2	0.0	0.000
Wildlife observation at night	14.0	14.9	13.2	0.910	22.7	0.0	0.000
Backcountry camping	10.6	4.5	15.8	0.000	9.0	13.3	0.060
Road cycling	7.1	7.6	6.7	1.000	8.3	5.4	0.119
Rock climbing	4.8	6.3	3.5	0.197	4.1	5.8	0.215
Rafting or canoeing	3.3	4.5	2.3	0.268	3.9	2.5	0.246
Horseback riding	2.9	1.7	3.8	0.097	3.6	1.7	0.119
Other	2.5	2.4	2.6	n/a	2.1	2.5	n/a
Fishing	0.5	1.0	0.0	0.111	0.8	0.0	0.235
Hunting	0.2	0.3	0.0	0.481	0.3	0.0	0.618

Note. Highlighted activities are those we classified as “night sky dependent.” [†] Fisher's exact.

Place Dependence

We asked night sky dependent recreationists about the importance of the park or monument they were surveyed at for night sky related activities. We used three statement items commonly used in the outdoor recreation behavior literature to assess “place dependence,” the extent to which a recreationist is dependent upon a particular place to participate in a specific activity (Williams & Roggenbuck, 1989). Almost half (49.2%) of night sky dependent recreationists surveyed agreed with the statement that the park/monument where they were surveyed was the best place for their nighttime activity (Table 5). Slightly less (39.4%) said they get more satisfaction out of their nighttime activity within that park/monument than any other place. And nearly one third (31.7%) of night sky dependent recreationists said they would not substitute any other area for their nighttime activity. There were no significant differences in place dependence between visitors to state parks versus national park units ($\chi^2 \leq 6.63$, $p \geq 0.16$). Generally, these data suggest night sky dependent recreationists are heavily dependent upon the parks and monuments in our study for the types of night sky recreation they participate in.

Utah's Night Sky Recreationists

Table 5. Proportion of respondents who disagree or agree with statements about the dependence of engaging in night sky dependent activities at the park in which they were intercepted.

Statement	Strongly disagree (%)	Somewhat disagree (%)	Neutral (%)	Somewhat agree (%)	Strongly agree (%)
[Park/Monument Name] is the best place for my night-time activity	3.9	7.6	39.3	32.2	17.0
I get more satisfaction out of my night-time activity at [Park/Monument Name] than any other place	2.9	8.9	48.8	27.7	11.8
I wouldn't substitute any other area for my night-time activity at [Park/Monument Name]	4.5	14.1	49.7	23.3	8.4

Note. $n = 382$. These questions were only asked of recreationists participating in a night sky dependent activity. No significant differences between visitors to state parks and national park units (chi-square ≤ 6.63 , $p \geq 0.16$).

Trip Type, Length, and Travel Distance

The vast majority (95.5%) of respondents indicated they were taking an overnight trip on the day they were surveyed; this was similar across both night sky dependent recreationists and other recreationists (Table 6). The mean length of overnight trips was 3.7 days. Night sky dependent recreationists did take significantly longer overnight trips relative to other recreationists (4.2 days for night sky dependent recreationists and 3.1 days for other recreationists, $p = 0.039$). Of the few respondents who were on day trips, the mean trip length was just over 12 hours and not significantly different when comparing night sky dependent recreationists to other recreationists.

Table 6. Trip type and length.

Trip Characteristic	Total ($n = 619$)	Night Sky Dependent Recreationists ($n = 386$)	Other Recreationists ($n = 233$)	Sig. Diff. (p -value) ^{††}
Trip Type				0.334 [†]
Overnight trip	95.5	95.9	94.9	
Day trip	4.5	4.2	5.2	
Trip Length				
Days if overnight trip (mean)	3.7	4.2	3.1	0.039 ^{††}
Std. Dev.	5.6	6.5	3.9	
Hours if day trip (mean)	12.1	10.8	13.8	0.452 ^{††}
Std. Dev.	9.8	9.5	10.3	

Note. [†]Pearson's chi-square. ^{††}Independent samples t-tests.

We also asked respondents to provide their home zip code towards the end of the survey. We used this information to calculate the travel distance and time from their home to the park unit where they were surveyed³. The mean travel distance for all respondents in the sample was just over 950 miles; there was no significant difference between night sky dependent recreationists and other recreationists (Table 7). The mean driving time was 879 min. (14 hours 39 minutes); again with no significant differences between night sky dependent recreationists and other recreationists.

As might be expected, we did find significant differences in travel distances and times when comparing visitors to state parks with visitors to national park units (Table 7). Visitors to national park units traveled an average of 147 miles further and 60 minutes longer to reach the park at which they were surveyed.

³ Home zip codes were converted to latitudes and longitudes using the Geoapify Geocoder (<https://www.geoapify.com/tools/geocoding-online>). Park unit latitudes and longitudes were generated for the primary visitor center within each park unit using Google Maps. Travel distances and travel times were calculated using the *georoute* command in Stata 16.1 (Weber & Péclat, 2017).

Utah's Night Sky Recreationists

Table 7. Trip distance and time

Trip Characteristic	Total (n = 577)	Night Sky Dependent Recreationists (n = 364)	Other Recreationists (n = 207)	Sig. Diff. (p-value)[†]	Utah State Parks (n = 273)	National Parks (n = 304)	Sig. Diff. (p-value)[†]
Travel distance (mean mi)	950.1	949.6	964.7	0.812	872.9	1019.5	0.016
<i>Std. Dev.</i>	729.7	717.9	755.1		743.0	711.5	
Travel distance (median mi)	741.5	743.8	742.9		610.5	827.3	
Travel time (mean min)	879.8	879.9	891.4	0.838	512.3	577.5	0.052
<i>Std. Dev.</i>	647.9	637.6	670.1		412.7	391.4	
Travel time (median min)	709.9	712.7	713.7		351.9	470.4	

Note. [†]Independent samples *t*-tests.

Night Sky Information and Management Preferences

There are consistent and significant differences between night sky dependent recreationists and other recreationists, in what and how they would like to learn about night sky resources (Table 8).

With regards to what recreationists would like to learn about night sky resources, 80.4% of night sky recreationists agreed with the statement that they would like more information about night sky viewing/astronomy prior to their visit while only 66.3% of other recreationists indicated they would like this type of information. Similarly, nearly 77.7% of night sky recreationists indicated they would like to receive information about ways to improve night sky viewing, compared to only 58.5% of other recreationists. Respondents continued to indicate interest, albeit less so, in more specific types of information, such as information about viewing wildlife at night or Native American connections to the night skies. While nearly 70% of night sky recreationists indicated they would like to receive information about Native American connections to the night skies, only 54.3% of other recreationists did. Interestingly, there were no differences between night sky recreationists and other recreationist in interest about viewing wildlife at night, with 57.3% all recreationists indicating an interest.

While there are significant differences in preferences for night sky related information between night sky dependent recreationists and other recreationists, it is important to note that there was a high level of interest across all recreationists in receiving information about night sky resources (Table 8). More than half of all respondents indicated a preference for at least some type of information about better ways to view night skies, cultural connections to night skies, or viewing wildlife at night.

Table 8. Preferences for night sky related information.

	Strongly disagree (%)	Somewhat disagree (%)	Neutral (%)	Somewhat agree (%)	Strongly agree (%)
All Recreationists (n ≥ 591)					
Night sky viewing/astronomy	3.6	4.4	16.9	38.7	36.4
Viewing wildlife at night	4.6	9.1	29.1	31.6	25.7
Native American connections to the night skies	5.3	6.6	24.0	32.8	31.3
Ways to improve night sky viewing	2.5	5.7	21.3	37.5	32.9
Night Sky Dependent Recreationists (n ≥ 362)					
Night sky viewing/astronomy*	3.2	3.2	13.2	39.4	41.0
Viewing wildlife at night	4.4	8.3	25.7	33.2	28.5
Native American connections to the night skies*	4.6	6.5	19.1	33.8	36.0
Ways to improve night sky viewing*	1.7	5.0	15.7	37.9	39.8
Other Recreationists (n ≥ 219)					
Night sky viewing/astronomy*	4.3	6.5	22.8	36.6	29.7
Viewing wildlife at night	4.9	10.6	34.5	28.8	21.2
Native American connections to the night skies*	6.4	6.9	32.4	30.6	23.7
Ways to improve night sky viewing*	4.0	7.1	30.4	36.2	22.3

Note. * Significant difference between night sky dependent recreationists and other dependent recreationists (chi-square ≥ 16.8, *p* ≤ 0.002). Data visualized in Appendix C, Figure C1.

Respondents also indicated clear preferences in how they would like to receive distinct types of night sky related information (Table 9). Across all four types of night sky related information we asked about, most respondents indicated a preference for ranger-led programs (34.5%), followed by smartphone applications (26.1%), interpretive displays (23.9%), and programs organized by local clubs (20.0%). Night sky dependent recreationists reported stronger preferences for receiving information about night

Utah's Night Sky Recreationists

sky viewing/astronomy across each of the four mediums we asked about (Table 9). Night sky dependent recreationists also indicated a stronger preference to receive information about Native American connections to the night skies via smartphone applications, relative to other recreationists.

Table 9. Proportion of respondents who want distinct types of night sky related information, by information source.

Statement	Ranger-led programs (%)	Programs organized by local clubs (%)	Interpretive displays (%)	Smartphone applications (%)
All Recreationists (n = 634)				
Night sky viewing/astronomy	46.5	33.0	34.4	36.8
Viewing wildlife at night	13.4	10.4	15.9	12.9
Native American connections to the night skies	25.4	15.5	24.0	24.1
Ways to improve night sky viewing	34.5	21.1	21.3	30.4
<i>Average across four types of information above</i>	<i>30.0</i>	<i>20.0</i>	<i>23.9</i>	<i>26.1</i>
Night Sky Dependent Recreationists (n = 388)				
Night sky viewing/astronomy	52.8*	37.6*	38.7*	41.0*
Viewing wildlife at night	15.2	11.3	17.3	14.4
Native American connections to the night skies	26.8	16.5	26.0	27.1*
Ways to improve night sky viewing	35.6	22.2	23.2	32.7
<i>Average across four types of information above</i>	<i>32.6</i>	<i>21.9</i>	<i>26.3</i>	<i>28.8</i>
Other Recreationists (n = 240)				
Night sky viewing/astronomy	37.1*	25.8*	27.9*	30.0*
Viewing wildlife at night	10.8	8.8	13.8	10.8
Native American connections to the night skies	22.9	13.8	20.8	19.6*
Ways to improve night sky viewing	32.9	19.2	18.3	27.5
<i>Average across four types of information above</i>	<i>25.9</i>	<i>16.9</i>	<i>20.2</i>	<i>22.0</i>

Note. * Significant difference between night sky dependent recreationists and other dependent recreationists ($\chi^2(1) \geq 4.5, p \leq 0.03$).

Respondents tended to support management actions that improved night sky recreation related experiences (Table 10). Specifically, between 85-90% of all respondents supported six of the seven distinct types of management actions we asked about. The management action of “restricting the number of lights visitors can use at night” was slightly less supported (74.2% of respondents indicating some level of support).

Night sky dependent recreationists did exhibit significantly more support for most of the management actions asked about, with the exception of “reducing the number of outdoor lights in the park,” “restricting the number of lights visitors can use at night,” and “adjusting the hues of lights to be wildlife friendly” (Table 10).

Utah's Night Sky Recreationists

Table 10. Support for different management actions.

Statement	Completely oppose (%)	Somewhat oppose (%)	Neither oppose nor support (%)	Somewhat support (%)	Completely support (%)
All Recreationists (n ≥ 609)					
Setting lights to the minimum necessary brightness	0.3	2.3	8.1	24.0	65.4
Reducing the number of outdoor lights in the park	0.7	2.1	10.6	22.3	64.4
Restricting the number of lights visitors can use at night	1.5	7.3	17.0	25.0	49.3
Creating shields on lights that direct light only to intended areas	0.7	2.3	12.1	20.6	64.4
Adjusting hues of lights to be wildlife friendly	0.3	1.6	10.6	20.6	66.8
Adjusting hues of lights to preserve human's night vision	0.5	1.6	13.3	25.0	59.5
Installing sensors/timers that turn lights on only when needed	1.5	1.5	8.8	21.5	66.7
Night Sky Dependent Recreationists (n ≥ 378)					
Setting lights to the minimum necessary brightness*	0.3	1.6	5.6	24.6	68.0
Reducing the number of outdoor lights in the park	0.5	2.4	8.2	22.4	66.6
Restricting the number of lights visitors can use at night	0.8	6.3	15.3	26.1	51.5
Creating shields on lights that direct light only to intended areas*	0.5	1.8	9.5	19.5	68.7
Adjusting hues of lights to be wildlife friendly	0.0	1.6	8.7	20.4	69.3
Adjusting hues of lights to preserve human's night vision*	0.3	1.6	9.2	26.7	62.3
Installing sensors/timers that turn lights on only when needed*	1.1	1.3	6.3	21.1	70.3
Other Recreationists (n ≥ 229)					
Setting lights to the minimum necessary brightness*	0.4	3.5	12.3	23.4	60.4
Reducing the number of outdoor lights in the park	0.9	1.7	14.7	21.7	61.0
Restricting the number of lights visitors can use at night	2.6	9.2	19.2	22.7	46.3
Creating shields on lights that direct light only to intended areas*	0.9	3.1	16.2	22.3	57.6
Adjusting hues of lights to be wildlife friendly	0.9	1.8	14.0	20.5	62.9
Adjusting hues of lights to preserve human's night vision*	0.9	1.7	20.2	22.8	54.5
Installing sensors/timers that turn lights on only when needed*	2.2	1.7	13.0	22.6	60.4

Note. * Significant difference between night sky dependent recreationists and other recreationists (chi-square ≥ 9.8, $p \leq 0.045$). Data visualized in Appendix C, Figure C2.

Expenditures

Mean trip expenditures across 12 discrete types of expenditures are reported in Table 11 and shown in Figure 2⁴. For all surveyed recreationists, the largest single cost was rental cars (mean = \$128.49; std. dev. = \$385.05) followed by fuel (mean = \$123.28; std. dev. = \$133.39), groceries and convenience foods (mean = \$114.46; std. dev. = \$276.92), and lodging costs (mean = \$102.84; std. dev. = \$234.24). We found no significant differences between night sky recreationists and other recreationists for any of the 12 types of expenditures asked about in the survey. This finding suggests night sky recreationists do not have significantly different trip-related spending patterns relative to other recreationists that we sampled. We discuss the implications of this finding in the discussion section below.

⁴ All trip expenditures were truncated at 3 standard deviations above the mean to minimize any effect that exceptionally large values on either descriptive statistics or comparative analyses.

Utah's Night Sky Recreationists

Table 11. Mean trip expenditures, by expenditure type

Expenditure type	All Recreationists (n ≥ 224)†		Night Sky Dependent Recreationists (n ≥ 151)†		Other Recreationists (n ≥ 72)†		Sig. Diff. (p-value)
	Total Costs (\$)	Costs per Day (\$)	Total Costs (\$)	Costs per Day (\$)	Total Costs (\$)	Costs per Day (\$)	
Rental cars	128.49	33.41	112.27	26.11	163.07	51.28	0.327
Std. Dev.	385.05		361.56		431.10		
Gas and oil (auto, RV, boat, etc.)	123.28	32.06	123.57	28.74	122.22	38.43	0.915
Std. Dev.	133.39		136.75		127.92		
Groceries and convenience foods	114.46	29.76	110.66	25.73	122.06	38.38	0.683
Std. Dev.	276.92		273.58		285.65		
Hotels, motels, resorts, lodges	102.84	26.74	99.24	23.08	111.08	34.93	0.698
Std. Dev.	234.24		221.27		259.95		
Restaurants and bars	92.73	24.11	92.93	21.61	89.97	28.29	0.805
Std. Dev.	111.87		113.47		107.37		
Camping fees (tent, RV)	84.44	21.96	90.00	20.93	75.25	23.66	0.108
Std. Dev.	95.65		102.18		82.71		
Souvenirs, clothing, supplies, other retail	53.47	13.90	57.01	13.26	46.13	14.50	0.170
Std. Dev.	68.68		72.82		59.23		
Park entrance fees	43.59	11.34	46.17	10.74	39.24	12.34	0.612
Std. Dev.	132.84		137.72		125.29		
Guides and tour fees	41.84	10.88	42.49	9.88	31.71	9.97	0.583
Std. Dev.	143.80		153.79		106.96		
Specialty lodging (e.g., B&Bs, hostels, cabins, vacation rentals)	19.05	4.95	21.32	4.96	14.68	4.62	0.618
Std. Dev.	93.30		98.48		82.89		
Recreation and entertainment expenses (e.g., movies, bowling, miniature golf, etc.)	17.79	4.63	21.69	5.04	9.03	2.84	0.120
Std. Dev.	56.74		65.91		28.25		
Equipment rental	11.16	2.90	10.43	2.43	12.74	51.28	0.692
Std. Dev.	41.34		40.61		43.23		
Other	5.06	1.32	6.42	1.49	2.25	51.28	0.320
Std. Dev.	11.77		13.63		5.94		
TOTAL	838.22		834.20		839.41		0.971

Note. † Excluding "other" expenditures.

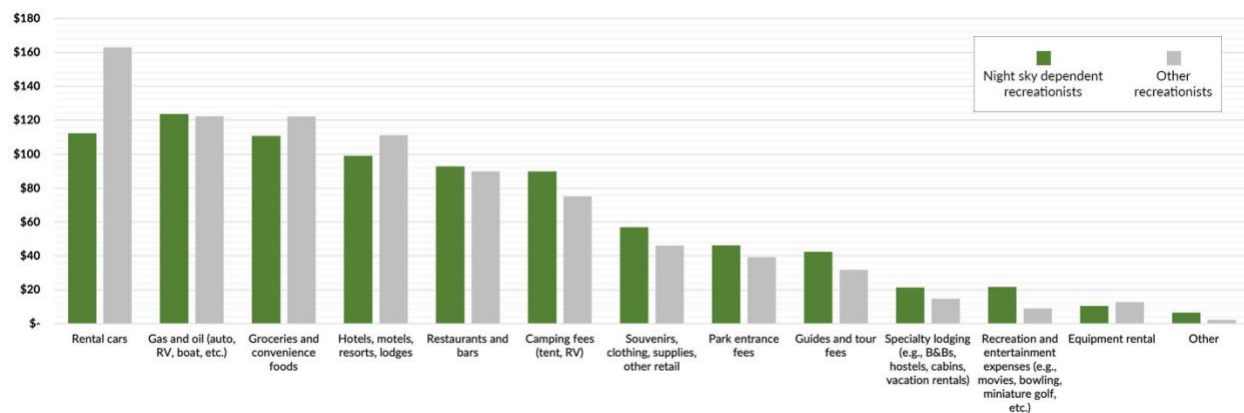


Figure 2. Per-trip expenditures of night sky dependent recreationists and other recreationists, by expenditure type. Asterisks indicate significant differences between night sky dependent recreationists and other recreationists.

Awareness and Importance of IDA Certification

Less than half (41.8%) of respondents knew that the park they were visiting was certified as an International Dark Sky Park. There were no significant differences between state park visitors (of which 43.6% were aware of the park's designation) and visitors to National Park Service units (40.2%). A significantly larger proportion of night sky dependent recreationists were aware of the park/monument's designation (46.6%) relative to other recreationists (34.1%) ($\chi^2(1) = 9.2, p = 0.002$).

Of those who were aware of the park's IDA certification ($n = 253$), two thirds (66.3%) said it was at least somewhat important for them to visit an IDA certified park. This proportion jumped to 73.8% for

Utah's Night Sky Recreationists

night sky dependent recreationists alone, a significant difference relative to other recreationists (Table 12; Figure 3).

Table 12. Importance of IDA Certification

Group	Not important at all (%)	Slightly important (%)	Somewhat important (%)	Very important (%)	Extremely important (%)
All Recreationists (n = 602)	19.6	14.1	31.6	21.8	13.0
Night Sky Dependent Recreationists (n = 370)*	12.7	13.5	29.5	26.5	17.8
Other Recreationists (n = 227)*	30.4	15.4	34.8	14.1	5.3

Note. * Significant difference between night sky dependent recreationists and other recreationists (chi-square = 51.2, $p \leq 0.001$).

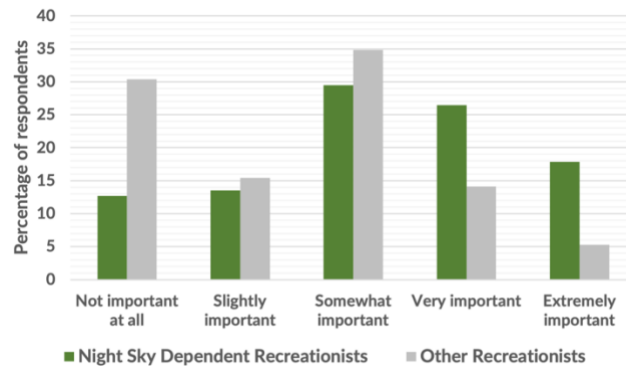


Figure 3. Importance of IDA certification across both night sky dependent recreationists and other recreationists for those who were aware of the park's IDA certification. Differences are significant at $p \leq 0.001$.

Perceptions of Awe

Recent work within the field of psychology has argued that “awe” is a unique emotional experience that individuals feel when they encounter a large or vast stimuli beyond their comprehension (Keltner & Haidt, 2003; Piff et al., 2015; Saroglou et al., 2008). Applied work focused on tourism experiences has suggests vast landscapes, including views of the cosmos, can elicit feelings of awe (Pearce et al., 2017; Rodrigues et al., 2022; Shiota et al., 2007). In their conceptual work, Coughlan and colleagues (2012) argue that feelings of awe can have important implications for resource and destination management. They argue exceptional physiological experiences, such as viewing a dark night sky luminated by hundreds of millions of stars, can cause individuals to create unique and memorable experiences which alter their own self-identity as well as their outlook on the rest of the world. The authors go on to argue that these transformative experiences can potentially influence subsequent travel behaviors as well as “place-protective” behaviors, such as taking action to preserve natural darkness (Coughlan et al., 2012).

While perhaps abstract in the aggregate, the awe experience is comprised of several relatively distinct dimensions which map to Coughlan and his colleagues’ ideas of physiological experiences, unique/memorable experiences, and changes to self-identity/worldview. These dimensions have been disaggregated by Yaden and colleagues (2019), who also developed a set of statement items to measure each of six unique dimensions of awe. These dimensions include:

- **Physical sensations** – physiological responses of the person experiencing the night sky. This can include feeling “frozen,” experiencing goosebumps or chills, eyes widening, and mouth opening (Chirico et al., 2017; Maruskin et al., 2012; Shiota et al., 2007).
- **Perceived vastness** – an appraisal of the conceptual or perceptual vastness of the night sky (Keltner & Haidt, 2003).

Utah's Night Sky Recreationists

- **A need for accommodation** – a feeling of difficulty in cognitively processing the experience (Keltner & Haidt, 2003).
- **An altered perception of time** – a feeling of time slowing or expanding during the experience (Rudd et al., 2012).
- **Self-diminishment** – an altered sense of identity, typically expressed as a perceived reduction in one's own body size (van Elk et al., 2016) or one's influence on a larger whole (Piff et al., 2015).
- **Connectedness** – a feeling of connection to other individuals or one's environment (Yaden et al., 2017).

We presented park visitors with a set of 19 statement items intended to measure the extent to which they experienced awe after looking up at the night sky for 30 seconds. These questions were only shown to recreationists if there was at least one star visible in the night sky (survey technicians noted this on the iPad before handing the tablet over to potential respondents). Ideally, we would have preferred these questions to be answered at a time when the night sky was darkest, but many were answered during late twilight when some stars were visible but the night sky was not at its most visible on the day the survey took place. The 19 statement items included 3-4 statement items intended to measure each of the six dimension of awe described above; these were drawn from Yaden and colleagues (2019). Table 13 shows responses across the six dimensions of awe. Perceived vastness was the most common feeling, with more than 80% of respondents indicating the view of the night sky made them feel like they were “in the presence of something grand” or that they generally “perceived vastness.” Feelings of self-diminishment were also strong, with over 75% of respondents indicating the night sky made them feel “small compared to everything else” or made them feel like they were shrinking. Most respondents also noted feeling an altered perception of time, with more than 60% reporting they felt their sense of time change, noticed time slowing, or sensed things momentarily slow down. While fewer respondents noted feelings of connectedness, a perceived need for mental accommodation, or feeling a physiological response relative to the dimensions mentioned above, these dimensions of awe were still reported by more than half of all respondents (Table 13).

Utah's Night Sky Recreationists

Table 13. Perceptions of awe.

Construct and Statement	Completely disagree (%)	Disagree (%)	Slightly disagree (%)	Neither disagree or agree (%)	Slightly agree (%)	Agree (%)	Completely agree (%)
A need for accommodation							
I felt challenged to mentally process what I was experiencing	2.7	9.9	9.9	25.2	16.2	18.0	18.0
I struggled to take in all that I was experiencing at once	1.8	6.3	6.3	32.4	18.0	13.5	21.6
I found it hard to comprehend the experience in full	1.8	7.2	4.5	26.1	15.3	24.3	20.7
Connectedness							
I felt closely connected to humanity	1.8	8.1	9.0	23.4	16.2	18.0	23.4
I had a sense of complete connectedness	0.9	3.6	0.9	26.1	17.1	30.6	20.7
I had the sense of being connected to everything else	1.8	1.8	3.6	22.3	18.8	25.0	26.8
Physical sensations							
It gave me chills	3.7	6.4	10.1	24.8	15.6	21.1	18.4
I felt my eyes widen	0.0	0.0	1.8	27.7	15.2	28.6	26.8
I felt myself smile	0.9	0.0	3.6	13.4	9.8	31.3	41.1
Self-diminishment							
I felt my sense of self become somehow smaller	1.8	6.3	3.6	23.4	15.3	27.0	22.5
I felt small compared to everything else	0.9	3.6	1.8	16.2	13.5	27.9	36.0
I felt my sense of self shrink	0.9	3.6	1.8	16.2	13.5	27.9	36.0
An altered perception of time							
I noticed time slowing	1.8	3.6	1.8	30.4	17.9	21.4	23.2
I felt my sense of time change	0.9	2.7	7.2	24.3	18.9	27.9	18.0
I sensed things momentarily slow down	0.0	0.9	3.6	20.9	20.0	31.8	22.7
Perceived vastness							
I experienced something greater than myself	0.9	0.0	4.5	18.9	10.8	30.6	34.2
I felt in the presence of greatness	0.0	0.9	2.7	19.1	6.4	33.6	37.3
I felt that I was in the presence of something grand	0.9	0.0	2.7	13.4	9.8	33.0	40.2
I perceived vastness	0.9	0.0	1.8	13.5	11.7	27.0	45.1

Note. ($n \geq 109$). Data visualized in Appendix C, Figure C3.

Sociodemographic Characteristics

The sociodemographic characteristics of the sample are reported in Table 14. Respondents, by and large, were middle age (mean age = 46.3), well educated (81.2% had at least a bachelor's degree), white (95.6%), and have an annual household income above \$100,000 per year (51% of respondents reported an income above \$100,000). The only statistically significant difference between night sky dependent recreationists and other recreationists were that night sky dependent recreationists tended to be slightly older (mean age of 47.5 relative to a mean age of 44.2 for other recreationists).

Utah's Night Sky Recreationists

Table 14. Sociodemographic characteristics of respondents

Sociodemographic Characteristic	Total (n ≥ 592)	Night Sky Dependent Recreationists (n ≥ 360)	Other Recreationists (n ≥ 226)	Sig. Diff. (p-value)
Age				
Mean age	46.3	47.5	44.2	0.016††
Std. Dev.	16.5	16.7	15.8	
Education (%)				
Some high school	0.2	0.3	0.0	0.775†
High school graduate	3.2	3.6	2.5	
Vocational/trade school	1.9	2.6	0.9	
Some college	8.0	7.5	8.9	
Associate degree	5.6	5.2	6.4	
Bachelor's degree	43.7	42.9	44.1	
Master's degree	25.5	26.0	25.4	
Professional degree	5.9	6.2	5.1	
Doctoral degree	6.1	5.7	6.8	
Gender (%)				
Male	54.3	52.2	56.9	0.529†
Female	44.8	46.7	42.2	
Other	1.0	1.1	0.9	
Hispanic (%)				
Yes	5.1	5.6	3.9	0.835†
Ethnicity (%)				
American Indian	0.7	1.1	0.0	0.215†
Asian	2.9	2.7	3.0	
Black	0.5	0.5	0.4	
Hawaiian or other Pacific Islander	0.3	0.0	0.9	
White	95.6	95.7	95.7	
Income (%)				
Less than \$25,000	4.9	5.3	4.0	0.163†
\$25,000 to \$34,999	4.6	5.8	2.7	
\$35,000 to \$49,999	5.9	7.2	4.0	
\$50,000 to \$74,999	16.2	14.4	19.5	
\$75,000 to \$99,000	17.4	16.4	19.0	
\$100,000 to \$149,000	23.8	23.6	24.3	
\$150,000 to \$199,999	12.3	11.1	13.7	
\$200,000 or more	14.9	16.1	12.8	

Note. [†]Pearson's chi-square. ^{††}Independent samples t-tests.

Discussion

We set out on this investigation with three distinct objectives which collectively provide data to inform the decisions of legislators, county and city governments, and outdoor recreation providers throughout Utah when it comes to decisions regarding night sky recreation. Each objective is reiterated below, followed by implications for these different audiences.

Objective 1. Evaluate the differences in trip characteristics between night sky recreationists and other outdoor recreationists who visit state and National Park Service units in Utah.

Anecdotally, one might believe that night sky dependent outdoor recreationists differ in *how* they participate in outdoor recreation relative to other outdoor recreationists. After all, night sky dependent outdoor recreationists must travel relatively long distances to reach the naturally dark, high-quality night skies that support their preferred outdoor recreation activities. Our findings suggest that night sky dependent recreationists participate in overnight and day trips at similar proportions as other recreationists we surveyed. For our sample of visitors to state and National Park Service units within Utah, this is predominantly (~95%) overnight trips. However, we did observe that night sky dependent recreationists do take significantly *longer* overnight trips relative to other recreationist (mean = 4.2 nights relative to 3.1 nights; Table 6). This finding has important implications for tourism professionals and destination marketing/management organizations that may be considering advertising their destination specifically to night sky recreationists. Knowing that night sky recreationists are more likely to stay longer in areas and

Utah's Night Sky Recreationists

communities around state parks and National Park Service units in Utah, these visitors are an enticing group to fill-up the local hotels, motels, and vacation rentals that support the economies of gateway communities, and more broadly the state. The work the Utah Office of Tourism is doing to promote night sky recreation destinations is on point, if their goal is to identify distinct types of recreationists who are likely to take longer trips. It is worth noting that there could be a chance the reason night sky dependent recreationists are taking longer trips is *because of* the Utah Office of Tourism's current and previous marketing efforts targeted at night sky recreationists. Allied organizations, such as destination marketing/management organizations are well positioned to follow suit and identify, market, and promote local destinations that support night sky recreation.

Objective 2. Characterize and compare the night sky related management preferences of night sky recreationists with those of other outdoor recreationists.

Night sky recreationists tend to hold stronger preferences for how dark sky resources are managed within dark sky parks/monuments, relative to other recreationists (Table 10). Our data suggest dark sky recreationists hold stronger preferences, relative to other recreationists, for a variety of management actions including:

- Setting lights to the minimum necessary brightness,
- Creating shields on lights that direct light only to intended areas,
- Adjusting the hues of lights to preserve human vision, and
- Installing sensors/timers that turn lights on only when needed.

While stronger preferences amongst night sky recreationists for management actions that preserve or improve night sky quality are expected, we did not expect such strong support for these types of management actions across the board, from all visitors within our sample. Between 85-90% of all respondents supported six of the seven distinct types of management actions we asked about. This finding suggests managers can take action to preserve and improve night sky quality, and receive support from the vast majority of visitors that may encounter the park when dark. Automated and passive management actions, such as setting lights to the minimum necessary brightness and installing sensors/timers that turn lights on only when needed, were more strongly supported relative to actions that would require active management, specifically restricting the number of lights visitors can use at night (Table 10). As noted throughout, our sample of visitors only occurred between 1-hour prior to sunset to 2- hours after sunset, and therefore is not a representative sample of all park visitors. However, when specifically asking about the preferences of outdoor lighting at night, our sample is much more relevant than a sample of all park users because the visitors in our sample are much more likely to encounter lighting at night. Therefore, managers can use the data in Table 10 as a barometer to assess evening time visitors' general willingness to accept potential management actions that they have yet to put in place.

When it comes to *how* outdoor recreationists would like to receive information about night sky resources/activities during their visit, the most popular source amongst visitors was ranger-led programs (Table 9). Notably, more visitors indicated a stronger preference for receiving information about night sky resources/activities from smartphone applications than either interpretive displays or programs organized by local clubs. These findings should reinforce the value of ranger-led programs and also highlight the burgeoning preference for receiving interpretation materials via smartphone apps.

Objective 3. Compare the expenditure patterns of night sky recreationists with those of other outdoor recreationists.

Given night sky recreationists take significantly longer overnight trips relative to other recreationists, isn't it also logical that dark sky recreationists spend significantly more during their

Utah's Night Sky Recreationists

travels? This may be more likely given the activities of night sky recreation often involve purchasing expensive equipment (e.g., cameras, telescopes, etc.). However, our data do not support this assumption that night sky recreationists have consistent and significantly different trip-related spending behaviors relative to other recreationists. We found no significant differences in trip related expenditures between night sky dependent recreationists and other recreationists. While night sky recreationists are a large proportion of visitors to state parks and National Park Service units in Utah (64.3% and 59.7% respectively in our sample), they do not appear to have notably different trip-related spending behaviors. So while night sky recreationists within Utah may be taking significantly longer overnight trips, they do not appear to be spending significantly more relative to other outdoor recreationists. This finding may highlight the need to characterize night sky recreationists as highly diverse within their own right; not just consisting of old, white, wealthy, well-travelled, star gazers. Rather night sky recreation can include many activities that cost very little, if anything. While we certainly did encounter, and survey, dozens of well to do tourists with expensive telescopes, we also surveyed dozens of night sky recreationists who were in the park just to “see what they could see.” If anything, the findings here suggest park managers should be aware that night sky recreationists are not just those individuals with deep wallets from far away, they also include visitors who spent very little to participate in their chosen outdoor recreation activities at night. Further, these finding also suggest that night sky recreation may simply be a part of the range of recreation opportunities most visitors chose to partake, rather than only a specialized activity. However, as mentioned throughout, our sample was taken beginning 1-hour before sunset to 2 hours after sunset, which resulted in ~95% of the sample being overnight visitors. Logic dictates that overnight users would have greater expenditures than daytime only users, and future studies should examine the differences between daytime only visitors and night sky dependent visitors.

Other Implications

While we have highlighted the implications of this study's three primary objectives, there are many other tangential insights and implications from the data collected and reported here. Without going into detail, these include:

- Finding that **night sky dependent recreationists are heavily dependent upon the parks and monuments in our study for the types of night sky recreation they participate in** (Table 5). Land management agencies, park managers, dark sky conservation groups, and others should know that these parks do offer unique experiences that park visitors may not be able to have otherwise. Dark sky resources are being diminished as populations grow and development encroaches upon park boundaries. Parks like those in our study may be a last bastion for the high-quality night sky activities they support.
- Finding that **less than half of respondents knew the park they were visiting was IDA certified**. While IDA certification may be important for recognizing the quality of a park's night sky, it does not appear to be a factor influencing most visitors' intention to visit a park.
- Finding that **perceptions of awe were strong amongst visitors**. The emotional experience of awe that visitors have may be referenced, or capitalized on, in efforts to promote place-protective behaviors such as limiting one's own light pollution or supporting dark sky conservation.
- Finding **most of visitors support management actions** that improve or protect the quality of the night sky.

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Appendix A: Sampling Protocol

1. Sampling Procedure

1.1. Logistics

We will be conducting surveys at four Utah National Park Service units and four Utah State Parks in 2022. Technicians will begin sampling in mid-April, and finish sampling by the end of May 2022. During each sample date, two technicians will be on-site surveying visitors.

Because this survey is focused on dark sky recreation, surveying will take place during evening and dusk hours. Technicians will survey visitors in parks for 2.5 – 3 hours a night. Surveying will start the hour before sunset each night, and will end by 10:00 pm. To allow for at least 1.5 survey hours during dark hours each day, we will not be surveying in June or July, because the sunset is after 8:30 pm (Table 1).

Table 1. Sunset times across different dates in 2021 for Moab and Bryce Canyon.

Date	Moab: sunset	Moab: end of civil twilight	Bryce Canyon: sunset	Bryce Canyon: end of civil twilight
April 15	7:55 pm	8:22 pm	8:04 pm	8:31 pm
May 15	8:23 pm	8:53 pm	8:31 pm	9:01 pm
June 15	8:44 pm	9:16 pm	8:51 pm	9:23 pm
July 15	8:41 pm	9:12 pm	8:49 pm	9:19 pm

Data from: <https://www.timeanddate.com/sun/usa/moab> and <https://www.timeanddate.com/sun/@5535943>

1.2. What to Take

Each technician will carry one iPads and a Sky Quality Meter (SQM). The survey instrument will be downloaded on each iPad for offline use in the Qualtrics application. The technicians will either read each question aloud to the visitor and mark their response or hand the iPad over to the respondent for them to complete on their own.

2. Where to Survey

2.1. National Park Service Units

Natural Bridges National Monument

- Campgrounds: Natural Bridges Campground (13 sites)
- Other survey locations: The visitor center; multiple parking lots along Bridge View Drive.
- Park hours: Open 24 hours.

Bryce Canyon National Park

- Campgrounds: North Campground (99 sites); Sunset Campground (100 sites).
- Other survey locations: The visitor center/fee station area; parking lot for Sunset Point.
- Park hours: Open 24 hours.

Capitol Reef National Park

- Campgrounds: Fruita Campground (71 sites).
- Other survey locations: The parking lot that goes to Panorama Point, Goosenecks Overlook, and Sunset Point; the visitor center.
- Park hours: Open 24 hours.

Arches National Park

- Campgrounds: Devils Garden Campground (51 sites).
- Other survey locations: The visitor center; near the entrance station.
- Park hours: Open 24 hours.

2.2. Utah State Parks

Antelope Island State Park

- Campgrounds: Bridger Bay Campground (26 sites); White Rock Bay Campground (20 sites); Ladyfinger Campground (5 sites).
- Other survey locations: The visitor center; near the entrance station.
- Park hours: 6 am – 10 pm

Utah's Night Sky Recreationists

Fremont Indian State Park

- Campgrounds: Castle Rock Campground (31 sites); Sam Stowe Campground (7 sites + 2 cabins)
- Other survey locations: The museum/visitor center.
- Park hours: 9 am – 6 pm.

Goblin Valley State Park

- Campgrounds: Goblin Valley State Park Campground (25 sites).
- Other survey locations: The visitor center/entrance station; parking lot near Observation Point.
- Park hours: 6 am – 10 pm.

Dead Horse Point State Park

- Campgrounds: Kayenta Campground (21 sites); Wingate Campground (31 sites)
- Other survey locations: The visitor center; near the fee station on road 313; parking area for Dead Horse Point Overlook.
- Park hours: 6 am – 10 pm.

3. On-site Protocol

Approach visitors and ask if they would be willing to participate in a survey that will take approximately 10 minutes. The purpose of the survey is to better understand the night sky experiences of visitors to state parks throughout Utah. If they are willing to participate, only survey one person per group. If there are multiple adults in a group, ask that the adult with the most recent birthday answer the survey. Do not survey any visitor under the age of 18.

Use your red light once it gets dark to light up the survey sign. People may ask what the red light is for. You can tell them that red LED lights minimize glare and reduce light pollution, allowing for better visibility of the night sky. Stay close to the survey sign once it is dark and do not survey folks at campgrounds after dark.

3.1. Refusals

If the visitor expresses that they do not currently have time to answer the survey, ask if they would be willing to fill out the survey later on their own time. If they agree, we will ask for their email address. The email can be entered into the iPad under the 'no, I do not wish to participate now' option on the first page. The question asking for the email pops up if they say they would be willing to take it later. If they do not wish to participate in the survey and don't want to provide their email, we would still like to get a few pieces of information about their visit. Three questions will pop up after they say 'no, I'm not willing to provide my email.' If they refuse this, just record the data in the subsequent screens based on what you observed.

3.2. Sky Quality Readings

At the end of the survey period, and once during the middle of the survey period, take a sky quality reading using the SQM. Take 4 readings each time, record them and email or text them to Jordan. The SQM values should be taken in a clear area, at least 25 ft away from buildings and lights, and not under trees. When taking measurements, the SQM should be held straight up, above head level. Either text or email your readings to Chase or Jordan after each shift.

Appendix B: Survey Instrument

Dark sky recreationists' experiences and expenditures in Utah National Parks



PAPERWORK REDUCTION and PRIVACY ACT STATEMENT: The Paperwork Reduction Act requires us to tell you why we are collecting this information, how we will use it, and whether or not you have to respond. We are authorized by the National Park Service Protection Interpretation and Research in System (54 USC §100702) to collect this information. The routine uses of this information will be for the benefit of NPS Managers and Planning staff in future initiatives related to the management of night sky recreation. The data collected will be summarized to evaluate visitor experiences, expectations, and support for management actions during their visit to this National Park unit. Your responses to this collection are completely voluntary and will remain anonymous. You can end the process at any time and will not be penalized in any way for choosing to do so. Your participation poses only minimal risks. Data collected will only be reported in aggregates and no individually identifiable responses will be reported. A Federal agency may not conduct or sponsor, and you are not required to respond to, a collection of information unless it displays a currently valid OMB Control Number (#####). We estimate that it will take about 10 minutes to complete and return this short survey. You may send comments concerning the burden estimates or any aspect of this information collection to: Dr. Jordan Smith, Associate Professor, jordan.smith@usu.edu; or Phadrea Ponds NPS Information Collection Coordinator at pponds@nps.gov.

Section 3: Trip characteristics

INTRO

Thank you for taking the time to complete this survey, which is being administered by Utah State University with support from the National Park Service and Utah State Parks.

Your responses will help guide future park planning efforts. Your answers are confidential and will not be connected to any identifying information.

Thank you again for sharing your time and insights with us today.

In this survey we define a “trip” as any length of time away from your primary residence.

About Your Trip

TOPIC AREA 3: TRIP PLANNING (ITIN23-MODIFIED)

Was this trip to [PARK]...

- ...the primary purpose for your trip? [IF SELECTED, SKIP TO DEST5-modified]
- ...one of several equally important destinations on your trip? [IF SELECTED, SKIP TO TRIP2]
- ...just an incidental or spur of the moment stop on your trip? [IF SELECTED, SKIP TO DEST5-modified]

NOTE: TRIP2 IS DISPLAYED ONLY IF [PARK] IS NOT Antelope Island SP.

TRIP2

What were the other destinations that were of equal importance as visiting [PARK]

- | | |
|---|---|
| ☐ Arches National Park | ☐ Grand Canyon National Park |
| ☐ Bryce Canyon National Park | ☐ Grand Parashant National Monument |
| ☐ Canyonlands National Park | ☐ Hovenweep National Monument |
| ☐ Capitol Reef National Park | ☐ Monument Valley Navajo Tribal Park |
| ☐ Dead Horse Point State Park | ☐ Natural Bridges National Monument |
| ☐ Fremont Indian State Park | ☐ Rainbow Bridge National Monument |
| ☐ Glen Canyon National Recreation Area | ☐ Zion National Park |
| ☐ Goblin Valley State Park | ☐ Other: _____ |
| ☐ Goosenecks State Park | |

TOPIC AREA 3: TRIP CHARACTERISTICS (DEST5-modified)

Is your current trip more than one day?

- Yes [IF SELECTED, SKIP TO TRIP5]
- No [IF SELECTED, SKIP TO TRIP4]

TRIP4

What is the total length of your trip to [PARK] in hours?

TRIP5

What is the total length of your trip to [PARK] in days?

Section 4: Residency

TOPIC AREA 1: RESPONDENT CHARACTERISTICS (RES2a)

Are you a permanent resident or citizen of the United States? (Please respond “yes” or “no”)

- Yes [IF SELECTED, SKIP TO RES2b]
- No [IF SELECTED, SKIP TO RES2c]

TOPIC AREA 1: RESPONDENT CHARACTERISTICS (RES2b)

What is your primary zip code?

TOPIC AREA 1: RESPONDENT CHARACTERISTICS (RES2c)

What is your country of origin?

Section 5: Trip Activities

Activities on this trip in [PARK]

TOPIC AREA 5: VISITOR USE AND RECREATION MANAGEMENT (ACT11-modified(a))

Below is a list of activities. Please indicate all activities you have or plan to participate in on this trip to [PARK].

Have, or plan to, participate in during this trip	
Scenic driving	☐
Developed camping	☐
Backcountry camping	☐
Wildlife observation during the day	☐
Wildlife observation at night	☐
Night sky photography	☐
Night sky viewing/astronomy	☐
Hiking	☐
Mountain biking	☐
Road cycling	☐
Horseback riding	☐
Hunting [DISPLAY ONLY IN Antelope Island SP]	☐
Fishing [DISPLAY ONLY IN Antelope Island SP]	☐
Visiting historic or cultural sites	☐
Rock climbing	☐
Rafting or canoeing	☐
Other: _____	☐

TOPIC AREA 5: VISITOR USE AND RECREATION MANAGEMENT (ACT11-modified(b))

Please indicate your primary activity during this trip to the park:

NOTE: Respondents can choose one activity from the list of activities they chose in ACT11-modified(a).

Section 6: Place Dependence

The importance of [PARK]

NOTE: PA4-modified IS ONLY DISPLAYED IF ONE OR MORE OF THE FOLLOWING CHOICES ARE SELECTED IN ACT11-modified: 'Night sky photography', 'Night sky viewing/astronomy', 'Wildlife observation at night'.

TOPIC AREA 3: TRIP CHARACTERISTICS (PA4-modified)

To what extent do you agree or disagree with the following statements?

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
[PARK] is the best place for my night-time activity.	-2	-1	0	1	2
I get more satisfaction out of my night-time activity at [PARK] than any other place	-2	-1	0	1	2
My night-time activity at [PARK] is more important to me than doing it at any other place	-2	-1	0	1	2
I wouldn't substitute any other area for my night-time activity at [PARK]	-2	-1	0	1	2

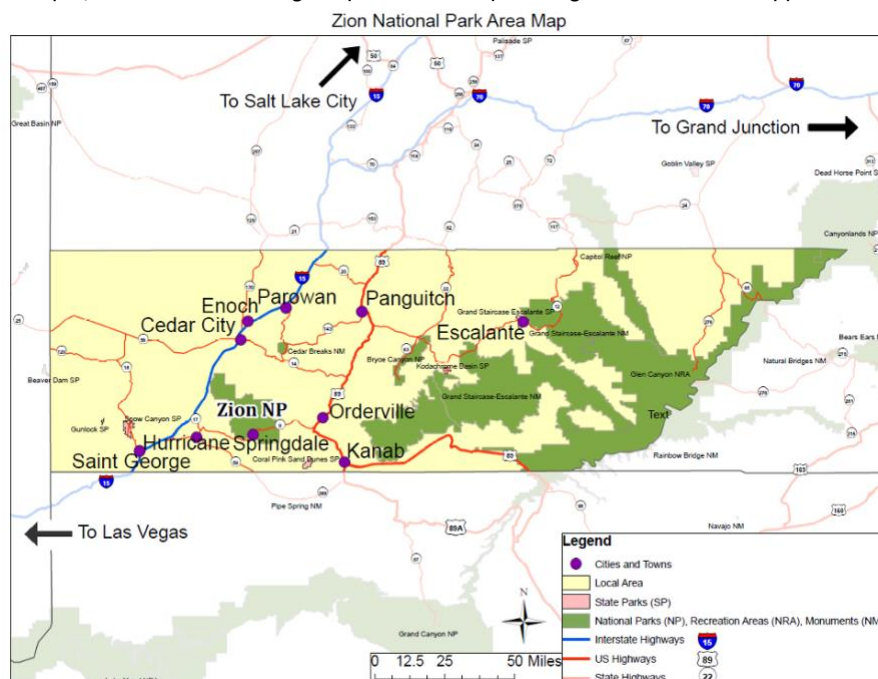
Section 7: Trip Expenditures

Expenditures in and around [PARK]

We would like to know about how much you spent in the local area on your trip. When providing estimates, please include only expenses in the area shown below.

ECONmap

A map of the area surrounding the park the survey is being conducted in will appear here. An example is provided below:



ECONskip

Have you or do you plan to spend money in the region indicated on the map above?

- Yes [IF SELECTED, SKIP TO ECON13]
- No [IF SELECTED, SKIP TO ECON3]

TOPIC AREA 9: EXPENDITURES (ECON13)

Please estimate how much you and those with whom you shared expenses (e.g., other family members, traveling companions) spent or plan to spend both inside [PARK] and within the nearby area on this trip.
Estimate expenditures as closely as you can. Please enter 0 if you did/will not spend any money in a particular category. If you don't know how much you spent in any category, please mark the "Don't Know" box.

	Amount spent in [PARK] and nearby area (in US\$)	Don't Know
Park entrance fees	-----	☐
Gas and oil (auto, RV, boat, etc.)	-----	☐
Rental cars	-----	☐
Restaurants and bars	-----	☐
Groceries and convenience foods	-----	☐
Hotels, motels, resorts, lodges	-----	☐
Specialty lodging (e.g., B&Bs, hostels, cabins, vacation rentals)	-----	☐
Camping fees (tent, RV)	-----	☐
Recreation and entertainment expenses (e.g., movies, bowling, miniature golf, etc.)	-----	☐
Souvenirs, clothing, supplies, other retail	-----	☐
Equipment rental	-----	☐
Guides and tour fees	-----	☐
Other (please list below)	-----	☐

TOPIC AREA 9: EXPENDITURES (ECON14)

How many people, including yourself, did you include in the estimates provided above?

	Number
Adults (18 years or over)	-----
Children (under 18 years)	-----

NOTE: ECON3 IS ONLY DISPLAYED IF ONE OR MORE OF THE FOLLOWING CHOICES ARE SELECTED IN ACT11-modified: 'Night sky photography', 'Night sky viewing/astronomy', 'Wildlife observation at night'.

ECON3

Please estimate your non-trip expenditures in Utah **related to night sky recreation** in the past 12 months. For example, did you purchase any equipment such as telescopes, cameras, camping gear, etc.? Please only include expenditures that you paid within Utah.

Section 8: Preferences for Visitor Services

Options to learn more about the night sky in [PARK]

ACTVS1

To be better informed on future visits, I would like to learn more about:

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
Night sky viewing/astronomy	-2	-1	0	1	2
Viewing wildlife at night	-2	-1	0	1	2
Native American connections to the night skies	-2	-1	0	1	2
Ways to improve night sky viewing	-2	-1	0	1	2
Other: _____	-2	-1	0	1	2

NOTE: if "Strongly disagree", "Somewhat disagree" or "Neutral" are chosen for all options, skip to MGMTOPT3-modified.

ACTVS3

How would you prefer to learn about the following activities? Please select all that apply.

NOTE: Only choices for which "slightly agree" or "strongly agree" are selected in ACTVS2 will be displayed below.

Respondents will be able to choose all that apply.

	Ranger-led programs	Programs organized by local clubs	Interpretive displays	Smartphone applications	Other (please describe)
Night sky viewing/astronomy	☐	☐	☐	☐	_____
Viewing wildlife at night	☐	☐	☐	☐	_____
Native American connections to the night skies	☐	☐	☐	☐	_____
Ways to improve night sky viewing	☐	☐	☐	☐	_____
Other	☐	☐	☐	☐	_____

Section 9: Support for Management Actions

Your opinion about how [PARK] manages lighting within the park

TOPIC AREA 8: ENVIRONMENTAL HEALTH AND RESOURCE MANAGEMENT (MGMTOPT3-modified)

Please indicate the degree to which you oppose or support the following management actions designed to protect the night sky quality at [PARK]

	Completely oppose	Somewhat oppose	Neither oppose nor support	Somewhat support	Completely support
Setting lights to the minimum necessary brightness	-2	-1	0	1	2
Reducing the number of outdoor lights in the park	-2	-1	0	1	2
Restricting the number of lights visitors can use at night	-2	-1	0	1	2
Creating shields on lights that direct light only to intended areas	-2	-1	0	1	2
Adjusting hues of lights to be wildlife friendly	-2	-1	0	1	2
Adjusting hues of lights to preserve human's night vision	-2	-1	0	1	2
Installing sensors/timers that turn lights on only when needed	-2	-1	0	1	2

Section 10: Awe

LOOK UP!

Now, we would like you to take 30-seconds to look up at the night sky and then answer a set of questions.

AWE

Please indicate the degree to which you disagree or agree with the following statement about the experience you just had viewing the night sky.

	Completely disagree	Disagree	Slightly disagree	Neither	Slightly agree	Agree	Completely agree
I sensed things momentarily slow down	-3	-2	-1	0	1	2	3
I noticed time slowing	-3	-2	-1	0	1	2	3
I felt my sense of time change	-3	-2	-1	0	1	2	3
I felt my sense of self become somehow smaller	-3	-2	-1	0	1	2	3
I felt small compared to everything else	-3	-2	-1	0	1	2	3
I felt my sense of self shrink	-3	-2	-1	0	1	2	3
I had the sense of being connected to everything else	-3	-2	-1	0	1	2	3
I felt closely connected to humanity	-3	-2	-1	0	1	2	3
I had a sense of complete connectedness	-3	-2	-1	0	1	2	3
I felt that I was in the presence of something grand	-3	-2	-1	0	1	2	3
I experienced something greater than myself	-3	-2	-1	0	1	2	3
I perceived vastness	-3	-2	-1	0	1	2	3
I felt in the presence of greatness	-3	-2	-1	0	1	2	3
I felt challenged to mentally process what I was experiencing	-3	-2	-1	0	1	2	3
I found it hard to comprehend the experience in full	-3	-2	-1	0	1	2	3
I struggled to take in all that I was experiencing at once	-3	-2	-1	0	1	2	3
I felt my eyes widen	-3	-2	-1	0	1	2	3
I felt myself smile	-3	-2	-1	0	1	2	3
It gave me the chills	-3	-2	-1	0	1	2	3

QUAL

Viewing the night sky can be affected by artificial light. We would like to know your opinion about how the night sky should look for stargazing or viewing. Please take a moment to look at the conditions of the night sky and answer the following question:

	Completely unacceptable	Unacceptable	Slightly unacceptable	Neutral	Slightly acceptable	Acceptable	Completely acceptable
How unacceptable or acceptable do you think the current conditions are in [PARK] for stargazing or viewing the night sky?	-3	-2	-1	0	1	2	3

Section 11: IDA Certification

NOTE: IDA1 ONLY DISPLAYED IF THE PARK IS NOT FREMONT INDIAN STATE PARK (as indicated in R1)

IDA1

Prior to this trip to [PARK], were you aware that this park is certified as an International Dark Sky Park/Place?

- ☐ Yes [IF SELECTED, DISPLAY IDA2]
- ☐ No [IF SELECTED, SKIP TO 'Socio-demographics']

IDA2

Please select one answer below.

	Not important at all	Slightly important	Somewhat important	Very important	Extremely important
How important was it for you to visit a park certified as an International Dark Sky Park/Place?	1	2	3	4	5

Section 12: Socio-demographics

TOPIC AREA 1: RESPONDENT CHARACTERISTICS (AGE1)

What is your age?

TOPIC AREA 1: RESPONDENT CHARACTERISTICS (EDUC1)

What is the highest level of formal education you have completed?

- ☐ Less than high school
- ☐ Some high school
- ☐ High school graduate
- ☐ Vocational/trade school certificate
- ☐ Some college
- ☐ Associate degree (AA, AS, etc)
- ☐ Bachelor's degree (BA, AB, BS, etc.)
- ☐ Master's degree (MA, MS, MEd, MSW, MBA etc.)
- ☐ Professional degree (MD, DDS, DVM, LLB, JD, etc.)
- ☐ Doctorate degree (PhD, EdD, etc.)

TOPIC AREA 1: RESPONDENT CHARACTERISTICS (GEND1-Modification)

What is your gender?

- ☐ Male
- ☐ Female
- ☐ Other

TOPIC AREA 1: RESPONDENT CHARACTERISTICS (RACE/ETH1)

For you only, are you Hispanic or Latino?

- ☐ Yes
- ☐ No

TOPIC AREA 1: RESPONDENT CHARACTERISTICS (RACE/ETH2)

Which of these categories best indicates your race? Answer only for yourself. Please select all that apply.

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or other Pacific Islander
- ☐ White

TOPIC AREA 9: EXPENDITURES (ECON9)

Which category best represents your annual household income?

- ☐ Less than \$25,000
- ☐ \$25,000 to \$34,999
- ☐ \$35,000 to \$49,999
- ☐ \$50,000 to \$74,999
- ☐ \$75,000 to \$99,999
- ☐ \$100,000 to \$149,999
- ☐ \$150,000 to \$199,999
- ☐ \$200,000 or more

TOPIC AREA 1: RESPONDENT CHARACTERISTICS (GROUP4)

How many people are in your group, including you?

Section 13: End

FINAL – this question will be displayed for respondents in National Parks

THANKS!!!

Thank you for taking the time to complete this survey. We appreciate your response.

NOTE: If the participant indicates that they prefer to participate in the survey via email, they will receive the following question at the site. The full survey will be emailed to the address they provide here.

R4

What is your email address?

Appendix C: Supplementary Figures

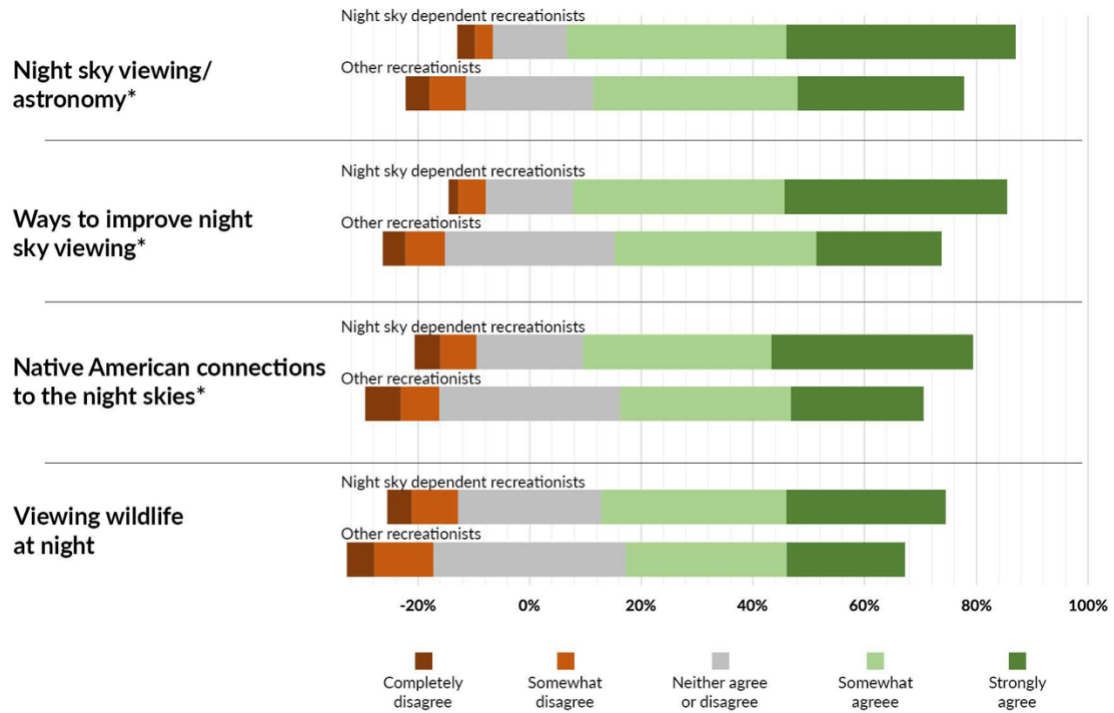


Figure C1. Preferences of night sky related information across both night sky dependent recreationists and other recreationists. Asterisks indicate significant differences between night sky dependent recreationists and other recreationists.

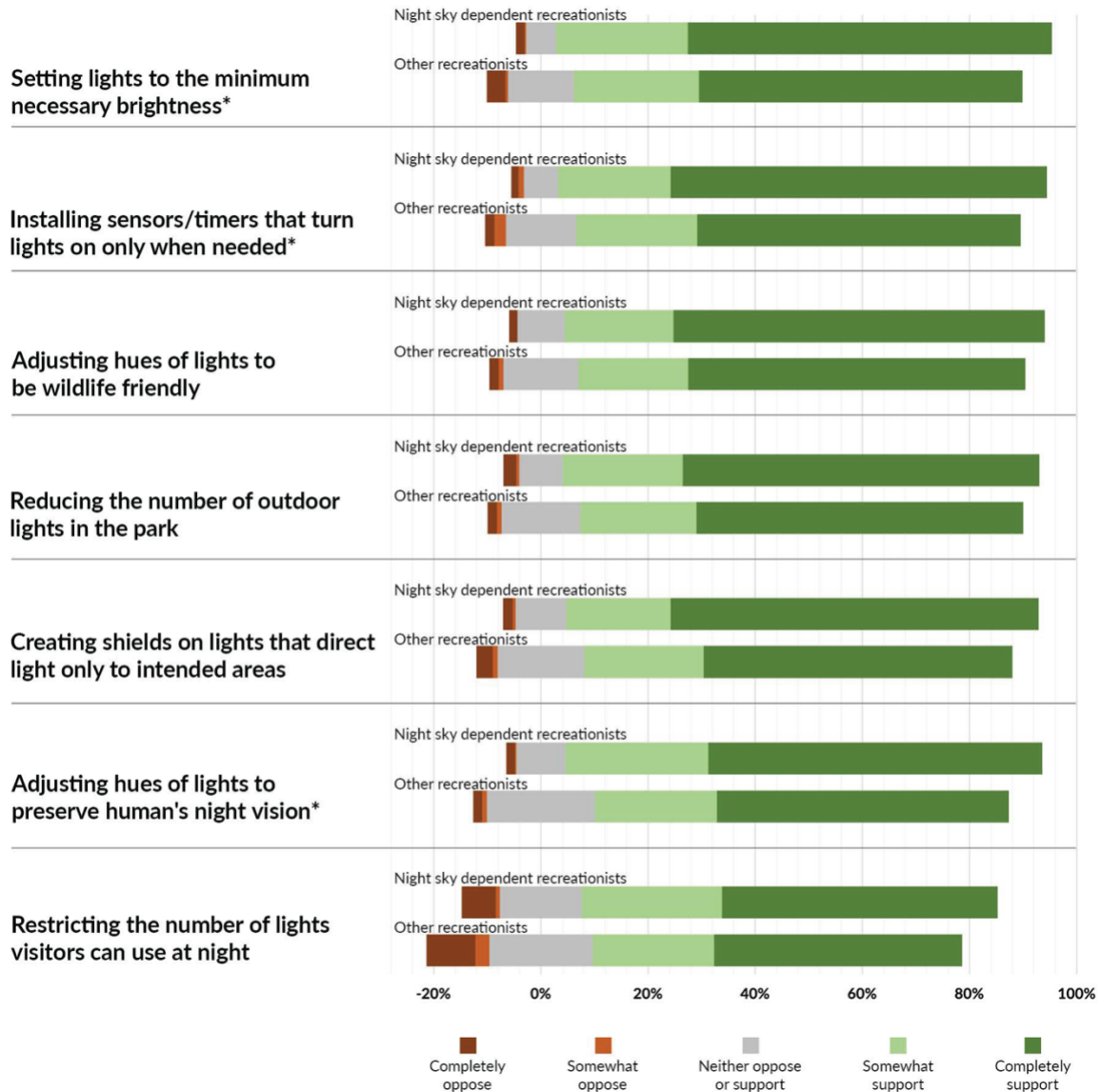
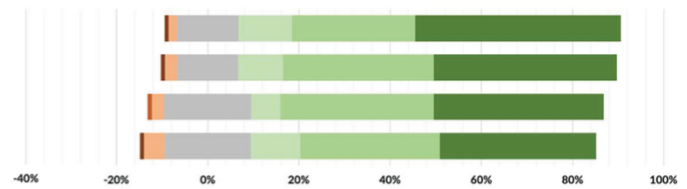


Figure C2. Support for different management actions across both night sky dependent recreationists and other recreationists. Asterisks indicate significant differences between night sky dependent recreationists and other recreationists.

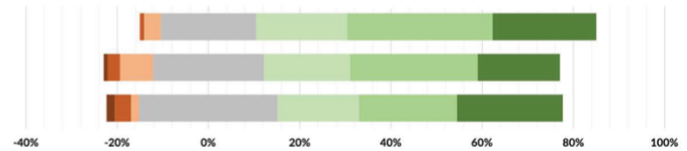
Perceived Vastness

- I perceived vastness
- I felt that I was in the presence of something grand
- I felt in the presence of greatness
- I experienced something greater than myself



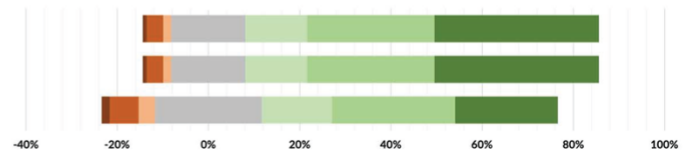
An Altered Perception of Time

- I sensed things momentarily slow down
- I felt my sense of time change
- I noticed time slowing



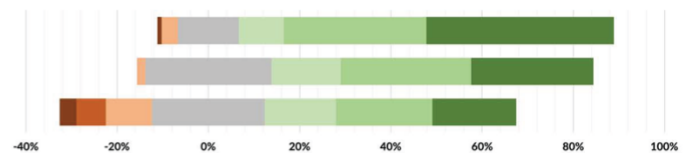
Self-Diminishment

- I felt my sense of self shrink
- I felt small compared to everything else
- I felt my sense of self become somehow smaller



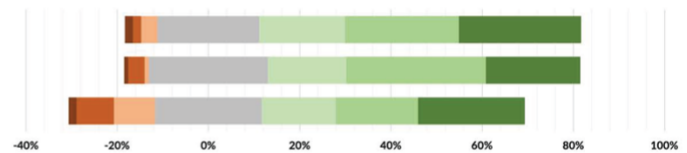
Physical Sensations

- I felt myself smile
- I felt my eyes widen
- It gave me chills



Connectedness

- I had the sense of being connected to everything else
- I had a sense of complete connectedness
- I felt closely connected to humanity



A Need For Accommodation

- I found it hard to comprehend the experience in full
- I struggled to take in all that I was experiencing at once
- I felt challenged to mentally process what I was experiencing

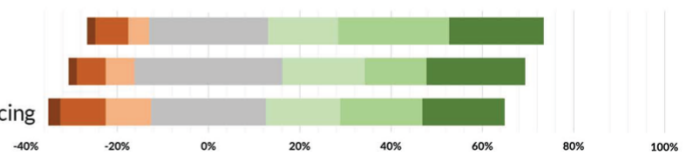


Figure C3. Dimensions and related statement items measuring feelings of awe.