

Dead Horse Point State Park International Dark Sky Park Designation Application Packet

January 2016



Photo of night sky from the yurts by Bret Edge

Crystal White, Assistant Park Manager

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Dead Horse Point State Park International Dark Sky Park Summary

Dead Horse Point State Park reflects the desired criteria for designation as a dark sky resource. Due to area remote character, the arid environment, low precipitation, distance from urbanization, and clear skies make this park an ideal candidate for connecting area residents and visitors with this superb natural dark resource. Park management is dedicated to preserving, protecting, and enhancing the natural darkness resource found within the park.

All of the criteria addressed under the gold-tier status requirements are met at Dead Horse Point State Park. Based on Dead Horse Point State Park's qualifications in each of the following categories designated by the IDA, we feel that the park should be considered for the Gold Tier designation.

1) Philosophy: Nighttime environments that have negligible to minor impacts from light pollution and other artificial light disturbance, yet still display outstanding quality night skies and have superior nighttime landscapes.

Though a few small communities are scattered throughout the area, DHPSP displays outstanding quality night skies despite a slight light dome from Moab and very little from any other communities, in nearly all points of the park.

2) Artificial Light and Skyglow: Typical observer is not distracted by glary light sources. Light domes are only dim and restricted to sky close to horizon.

From the majority of areas throughout the park, very little light impact is noticed at all. At the visitor center, a small light dome from Moab is visible however hugs tight to the horizon and is mostly blocked by Behind the Rocks Wilderness Area.

3) Observable Sky Phenomena: The full array of visible sky phenomena can be viewed.

On a clear night, the Milky Way is visible, faint meteors can be seen, ISS can be observed passing overhead, clouds look like black patches in the night sky and zodiacal light can be seen from any location within the park.

4) Nocturnal Environment: The area is devoid of obvious lights that can cause wildlife disorientation. Artificial light levels are thought to be below the threshold for plant and animal impact. Ecological processes related to nocturnality are unaltered. There is no lighting atop towers or buildings within park boundary.

The nocturnal animals have not been affected by any lighting within the park. A kit fox that lives close to the visitor center is seen frequently hunting along its historic area with no apparent effect from the visitor center lights. There are no lights within the park on towers or on top of buildings. All sodium lights have been unplugged and are scheduled for removal in 2016.

5) Visual Limiting Magnitude: Equal or greater than 6.8 under clear skies and good seeing conditions.

The NPS Night Skies Team has determined VLM data for Dead Horse Point State Park at 7.1. In 2015, the Night Skies Team measured a Zenith Limiting Magnitude of 7.1.

6) Bortle Sky Class: 1-3.

The NPS Night Skies Team has determined a Bortle class of 2 for Dead Horse Point State Park's night skies, based on measurements from multiple nights.

7) Unihedron Sky Quality Meter: >21.59.

The National Park Dark Skies Team did an assessment of Dead Horse Point State Park's night sky in the summer of 2015. Their report stated that the Park was rated 2 in the Bortle scale. The SQM was listed at 21.59 putting the Park within the gold tier of dark sky designation. Report to follow.

Dead Horse Point State Park staff has a basic Unihedron zenith model sky quality meter and have collected data during times of new moon. On two separate nights (Dec 2015 to Jan 2016), staff measured sky quality at 7 distinct sites within the park. The average of these SQM measurements is 21.39. 3 of 7 sites measured well above 21.50 with zero under 21.00. Park staff have committed to completing sky quality meter collection at least eight times within each year to ensure the quality of the night sky does not diminish.

Nomination Letter



GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

State of Utah

DEPARTMENT OF NATURAL RESOURCES

MICHAEL R. STYLER
Executive Director

Division of State Parks and Recreation

FRED HAYES
Division Director

December 8, 2015

Board of Directors
International Dark-Sky Association
3225 North First Avenue
Tucson, Arizona 85710

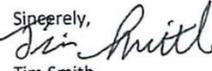
Dear Board of Directors:

I am writing to support the designation of Dead Horse Point State Park as an International Dark Sky Park (IDSP). Dead Horse Point State Park, located southwest of Moab, Utah and straddling the Grand/San Juan County line was established in 1959 with land donated to the state by San Juan County. The county recognized that the scenic qualities of Dead Horse Point should be preserved while being enjoyed by visitors. They decided that the newly formed state park system would offer proper management of the area. The park has grown from the original 628 acre gift to more than 5,300 acres through acquisitions from the Bureau of Land Management and other state agencies.

IDSP designation would assist Utah State Parks in celebrating and protecting this popular resource. Protection from light pollution was identified as an important recommendation in Dead Horse Point's 2007 Resource Management Plan. We have made it a key region priority in expending funds to retrofit lighting to protect the night sky and meet standards required of an IDSP. Our staff has worked with neighboring oil producers on BLM administered lands to reduce their lighting to better protect the night skies of Dead Horse Point and Canyonlands National Park. Every action or new development at Dead Horse Point is now viewed within the context of protecting the night sky.

We have seen firsthand the interest, popularity and hunger of our visitors for pristine night skies. Among our most well-attended of interpretive programs are night sky programs, including star parties, full moon hikes and other programs crafted around celestial events. We are committed to the expectations of an educational program celebrating the night sky inherent in this designation, not just because it is required, but because it is appreciated and desired by our visitors.

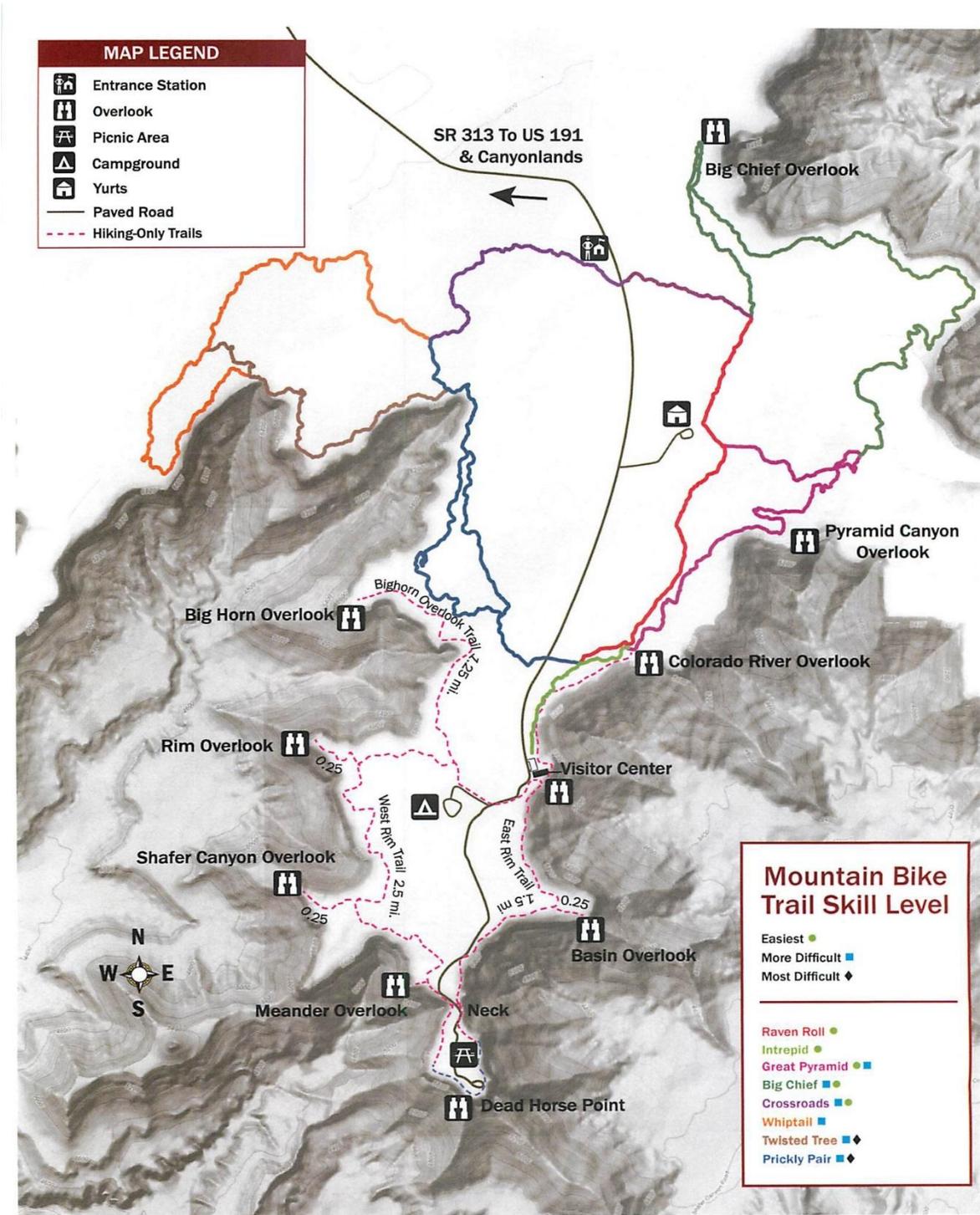
We appreciate your consideration of this request. The designation would assist in the protection of the night sky at Dead Horse Point and expand the awareness and value of this asset within Utah State Parks and the state of Utah.

Sincerely,

Tim Smith
Southeast Region Manager
Utah State Parks



Southeast Region, 1165 S. Highway 191, Suite 7, Moab, UT 84532-3062
telephone (435) 259-3750 • facsimile (435) 259-3755 • TTY (801) 538-7458 • www.stateparks.utah.gov

Map of Dead Horse Point State Park with Highway 313 and Trails Included



Dead Horse Point State Park's Night Sky Resources

Location and Description of Park

Dead Horse Point State Park, located southwest of Moab, Utah, and straddling the Grand/San Juan County line, was established in 1959 with land donated to the State by San Juan County. The County recognized that the scenic qualities of Dead Horse Point should be preserved while being enjoyed by visitors. They decided that the newly formed state park system would offer proper management for the area. The Park has grown from the original 628-acre gift to more than 5,300 acres through acquisitions from the Bureau of Land Management and other state agencies.

The large shelter at the main viewpoint, built in 1961, was the first visitor facility constructed at the park. A rock wall and paved trails were added to the viewpoint from 1961 to 1963. The Park's original visitor center was built in two phases during 1965 and 1967. The visitor center was completely remodeled in 1999 to improve and update the exhibits, offices and information area, and to provide better access for visitors with disabilities. The campground was completed in 1971, but was not opened for use until 1973. The road to the Park was paved in 1974. Backcountry trails were developed in 1982, and expanded in 1998. There are currently 10 miles of hiking trails in the Park. A group campsite (now yurt site) was developed in 1990. In 2006, a new entrance station was constructed near the park boundary and the picnic area was improved. In 2009 a mountain bike trail system of 8 miles was added to the park and extended in 2014 to a 17 mile trail.

Dead Horse Point State Park is located about 20 miles off US Highway 191 on State Road 313, 35 miles from Moab, Utah. The Park is approximately 245 road miles south of Salt Lake City and adjacent to Canyonlands National Park. The Park contains approximately 5,300 acres that include developed and backcountry areas with magnificent views of multi-hued cliffs, canyon rims, mountains, and mesa top.

Ecology and Geology

The Park supports a variety of desert plant and animal life. The plants and animals that thrive in the Park have adapted to the area's harsh, dry climate.

The Park supports more than 90 different species of desert plants including juniper, pinion, single-leaf ash, live oak, sagebrush, rabbitbrush, buffaloberry, squawbush, cactus, yucca, as well as native grasses and many seasonal wildflowers that have adapted to the high desert climate. No plant species of special concern have been identified in the Park.

Over 100 species of animals potentially inhabit or visit the Park. Like the plant life, many of the animals at Dead Horse Point have adapted to living in the harsh desert environment. Resident mammals include desert bighorn sheep, mule deer, black-tailed jackrabbit, desert cottontail, and rock squirrel.

Birds are the most numerous animals by species. Golden eagles, peregrine falcons, and ravens are among the 63 species of birds listed on the Park's bird list. Many bird species nest in the Park; others are transient or seasonal visitors.

Sagebrush lizards, eastern fence lizards, gopher snakes and other reptiles inhabit the Park, along with one amphibian, the red-spotted toad.

The Park has identified seven animal species from the State of Utah Sensitive Species List that may be located in the Park. The Mexican spotted owl is federally listed as threatened. The ferruginous hawk, burrowing owl, Townsend's big-eared bat, big free-tailed bat, spotted bat, and the kit fox are all listed by the state as wildlife species of concern.

Geological Resource

The awe-inspiring views from Dead Horse Point are the Park's most important resources. Those vistas include two thousand vertical feet and 300 million years of geologic history. At 12,721 feet, Mount Peale in the La Sal Mountains is the highest point visible from the park. The Colorado River at approximately 3,900 feet is the lowest visible point. Mesa top elevations in Dead Horse Point State Park range from 5,900 to 6,000 feet.

The Park sits on top of a visible column of rock that contains no fewer than 13 distinct layers. These layers represent a time line that extends from the Pennsylvanian Honaker Trail formation, deposited 295 to 305 million years ago, to the Jurassic Kayenta Formation, deposited around 190 million years ago.

Human History

There is evidence that humans have used the area that includes Dead Horse Point for at least 10,000 years. The earliest inhabitants, the Paleo-Indian culture, followed by the nomadic archaic people, are known by stone tools and rock art found in the area. By 500 A.D., both the Ancestral Puebloan and Fremont peoples had settled in the area, remaining until the widespread exodus of the region by both cultures in the 1300s. These peoples foraged for native plants, hunted game such as bighorn sheep, deer, and rabbits, and grew crops of maize and beans. They used the Dead Horse Point area for hunting.

The Ute and Paiute cultures may have arrived in the area as early as A.D. 800. The Navajo migrated to the area after 1300A.D. These cultures were still using the area when the first Europeans entered southeastern Utah, and are still in the general area today.

The first Europeans to explore southeastern Utah were Spaniards. They entered the area searching for travel routes to the Spanish missions in California. The Old Spanish Trail that linked Santa Fe and Los Angeles traversed the Moab Valley and Moab Canyon, past the current entrance to Arches National Park.

The first European settlement in the area was a result of the Mormon Church's colonization efforts. The Mormons attempted to establish the Elk Mountain Mission in 1855, but conflicts with the Utes led them to abandon their efforts. It took until 1878 for settlers to return and establish the farming and ranching community of Moab (the gateway community for Dead Horse Point State Park). The area's economy was based on farming, ranching and fruit growing until the uranium boom of the 1950s brought in thousands of prospectors, miners, workers, and speculators. This boom brought new motels, stores, restaurants, schools and businesses to the area. The demand for uranium decreased, and by the 1980s this industry ceased to be an important part of the economy. The mining of potash (used as fertilizer) has been an important part of the local economy since the early 1960s. Potash is mined just east of Dead Horse Point using a solution process. The mine's evaporation ponds are visible from the Park.

Since the mid-1980s, tourism has been the area's largest and arguably, most important industry. The outdoor recreation possibilities of the area have been promoted as early as 1906. The establishment of Arches National Monument in 1929 (designated a national park in 1971) brought national interest to the area. Interest in river running, and the designation of Canyonlands National Park in 1964 further enhanced the area's notoriety. Since 1949, the region has been a popular location for filming movies, commercials and advertisements. All of these factors, plus the boom in mountain biking starting in the mid-1980s, led to an increase of visitors to the area.

Cultural Resources

Dead Horse Point State Park is located in an area known for cultural resources, particularly the indigenous prehistoric cultures. Humans first visited the area surrounding Dead Horse Point over 10,000 years ago. Nomadic hunter-gatherers roamed through southeastern Utah from 8,000 B.C. to 500 B.C. They exploited wild plants in addition to hunting big and small game. They left little in the way of artifacts or structures, but did make intriguing petroglyphs and pictographs on the canyon walls of the area. The Park is located on the boundary of the contemporaneous Fremont and Ancestral Puebloan cultures. These people were agriculturalists and developed unique settlements. There are numerous Fremont and Ancestral Puebloan sites in the area. There is evidence that the historic Utes moved into the area approximately 1,000 years ago. The Park does contain significant archeological resources including remnants of rock shelters, some rock art, stone tools, and lithic scatter.

Natural Darkness Resource

The Park recognizes dark skies as an important natural resource as demonstrated by inclusion in the Resource Management Plan 2007 and the Interpretive Plan 2013.

The Resource Management Plan(RMP) of 2007 states under the six primary vision elements, "Protecting and preserving park resources by exercising good stewardship practices. Offering engaging and interesting interpretive and educational programs that enhance the visitor's experience and appreciation for the park and surrounding landscape". Under resource management the RMP states, "Work with counties to put in place light ordinances for viewshed". (RMP pg.1) It also states, "Inventory resources as necessary". (RMP pg. 2) Within "Inventory resources" it follows that natural darkness, which the stakeholders saw to include in considering the protection of the viewshed, is included.

Under the Mission and Vision in the RMP, the mission statement is listed as, "The mission of Dead Horse Point State Park is to provide a variety of quality recreational and educational opportunities to visitors, have a positive impact on the local and state economies, and promote and ensure the protection of park resources, viewshed and environment". Within the vision statement is stated, "Providing management that maintains traditional experiences, while also allowing for other appropriate types of non-traditional activities to occur in the Park". This statement allows for the recent addition (last 5 years) of night sky programs and allowing stargazers and astrophotographers unrestricted access to overlooks for night sky viewing. It also states within the vision statement, "Protecting and preserving park resources by exercising good stewardship practices". This includes limiting the light pollution coming from within the park as well as working with other land management agencies to put in place ordinances for lighting policies. (RMP pg.3)

In the RMP's park resources can be found the following statement, "The Park's primary resource is the spectacular viewshed". The RMP has already identified the night sky as being part of the viewshed as mentioned in the second paragraph of this section. (RMP pg. 11)

In the resource management section of the RMP it states, “Key Issues” with the first being, “Protect the Park viewshed by having a cooperative interagency visual management plan for viewshed area, act to minimize visual impacts, Support land trades and acquisition to protect viewpoints, work with counties to put in place light ordinances for viewshed, and blend development into natural setting”. (pg. 22) Again they mention the night sky as a resource and crucial part of the viewshed that must be protected by help put in place light ordinances.

The Interpretive Plan (IP) of 2013 states in the vision statement, “Dead Horse Point State Park will accomplish its interpretive mission by ensuring the topics of all programming efforts reflect the preservation of park resources and education for attendees”. (IP pg.1) Listed under the resources to be interpreted is found, “The natural darkness found with the Colorado Plateau reveals a myriad of stars, and many other universal objects”. Within the audience for interpretive program, both stargazers and astrophotographers have been identified. (IP pg.2)

The IP lists formal interpretive efforts to include night sky programming, and informal interpretive programming to include a night sky brochure highlighting what makes a park a “Dark Sky Park”, how Dead Horse Point State Park has adjusted the exterior lighting throughout the park to be night sky friendly and how they as visitors may assist the park in protecting the natural darkness found within. (IP pg. 3)

The partnership between Arches and Canyonlands National Parks, and Dead Horse Point State Park to provide quality night sky programming is identified within the Plan in this statement, “Dead Horse Point State Park is partnered with Arches National Park and Canyonlands National Park to present night sky programs to area visitors. These programs will rotate from park to park with night sky rangers from each park present. All three parks are park of the Colorado Plateau Dark Sky Cooperative with Canyonlands National park and Dead Horse Point State Park in the process of becoming dark sky parks”. (IP pg.3-4)

Found within these Plans, it is clear that the Park’s management team is committed to improving the Park’s exterior lighting to increase night sky friendly lighting, work with outside land managers to improve light trespass coming from outside of the park and implement lighting practices and policies that will protect the natural darkness found within the Park, and to educate area visitors of the lighting practices found within the park and the night sky resource that is visible from within the park.

Climate

The climate at Dead Horse Point is temperate and arid, with annual precipitation averaging about 10 inches and average daily solar resource of 6.5 hours per day. From July through early September, thunderstorms advance from the Pacific Ocean off the coast of Mexico and Southern California. Frontal-type storms out of the Northwest move through the area from October through June.

The highest amount of precipitation occurs from July through October due to monsoonal moisture coming from the Gulf of Mexico and eastern Pacific. Summer temperatures vary approximately 30 degrees F, with highs in the mid 90's and lows around 60 degrees. Winters at Dead Horse Point have a temperature range of about 22 degrees F; with highs in mid 40s and lows of about 22 degrees F. Annual snowfall at the Park generally averages 26 inches.

Utah's Annual Precipitation Map

Dead Horse Point State Park's approximate location marked by white star

Average Annual Precipitation

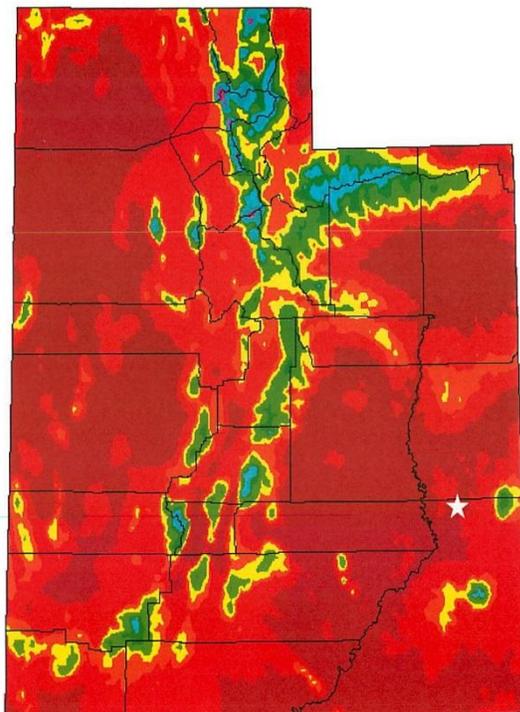
Utah



Period: 1961-1990

This map is a plot of 1961-1990 annual average precipitation contours from NOAA Cooperative stations and (where appropriate) USDA-NRCS SNOTEL stations. Christopher Daly used the PRISM model to generate the gridded estimates from which this map was derived; the modeled grid was approximately 4x4 km latitude/longitude, and was resampled to 2x2 km using a Gaussian filter. Mapping was performed by Jenny Weisburg. Funding was provided by USDA-NRCS National Water and Climate Center.

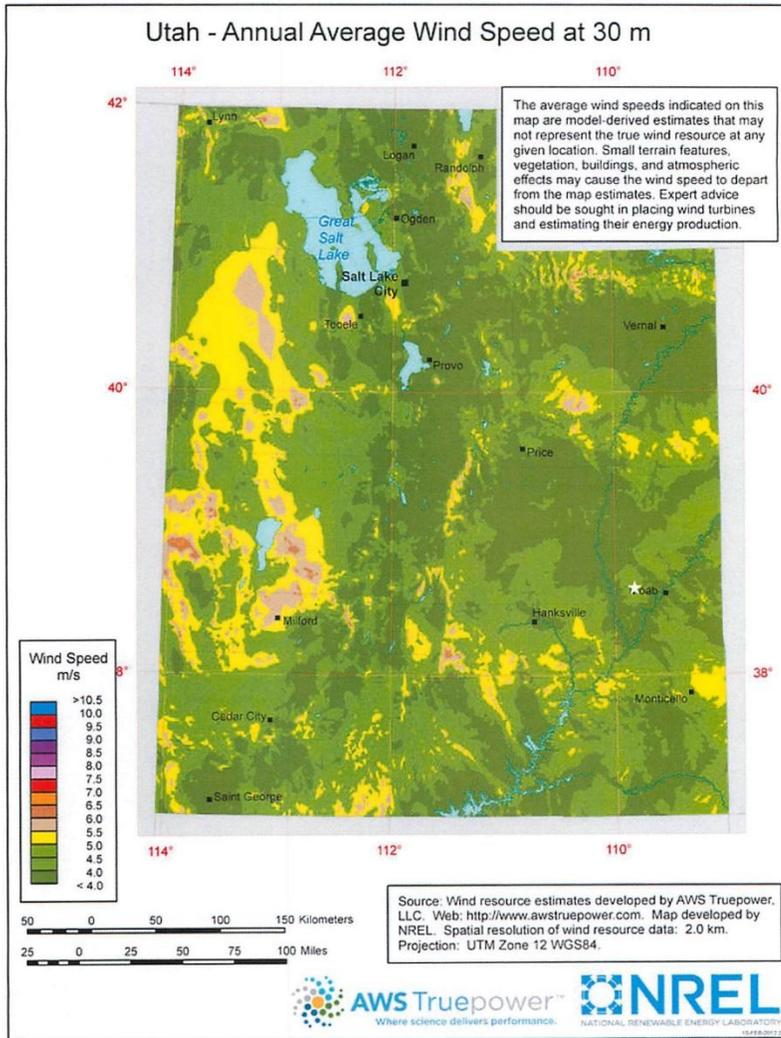
12/7/97



Wind storms can kick up a lot of debris and sand in desert environments. On occasion, wind speeds can pick up to 40-70 mph as they cross the mesa top within the park. For Dead Horse Point State Park, the annual average wind speed is below 6 mph. With a low average wind speed, the result is a reduction of air particulates common in wind storms.

Utah's Annual Average Wind Speed Map

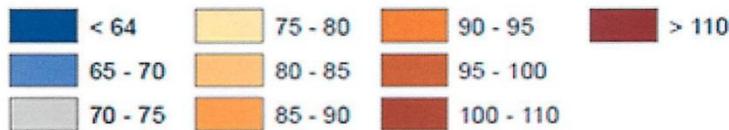
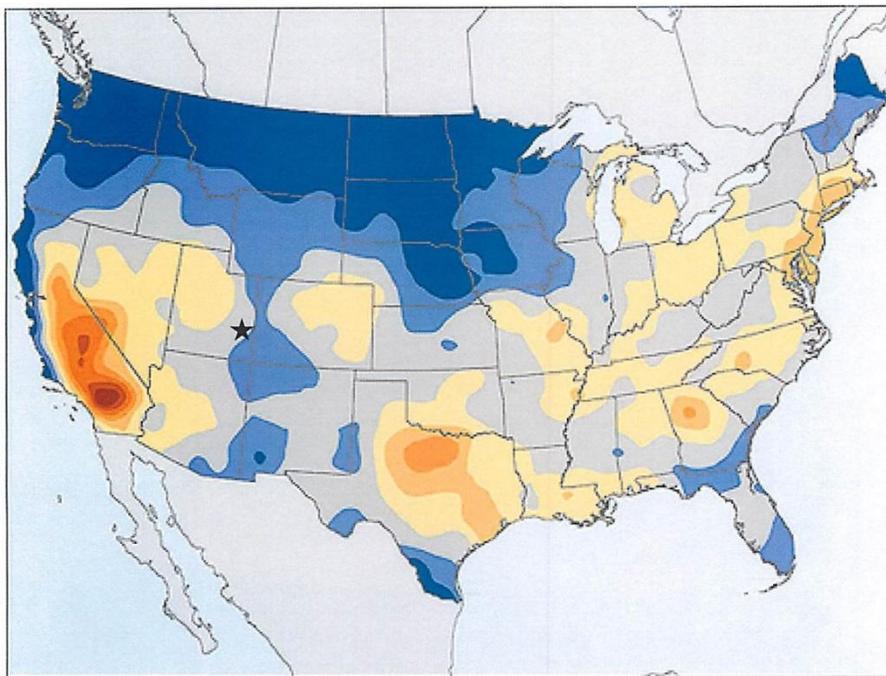
Dead Horse Point State Park's approximate location marked by white star



Dead Horse Point State Park is a Class I area under the Clean Air Act, which requires that the park receives the highest level of air-quality protection. Consequently, Canyonlands National Park (our neighbor) participates in the National Park Service's comprehensive air resources management program, designed to assess air pollution impacts and protect air quality related resources. We are able to assess our air pollution impacts based off the studies completed by the National Park Service and are committed to ensure minimal impacts from Dead Horse Point State Park on local air quality.

Air Quality Index for Southwestern States

Dead Horse Point State Park's approximate location marked by black star



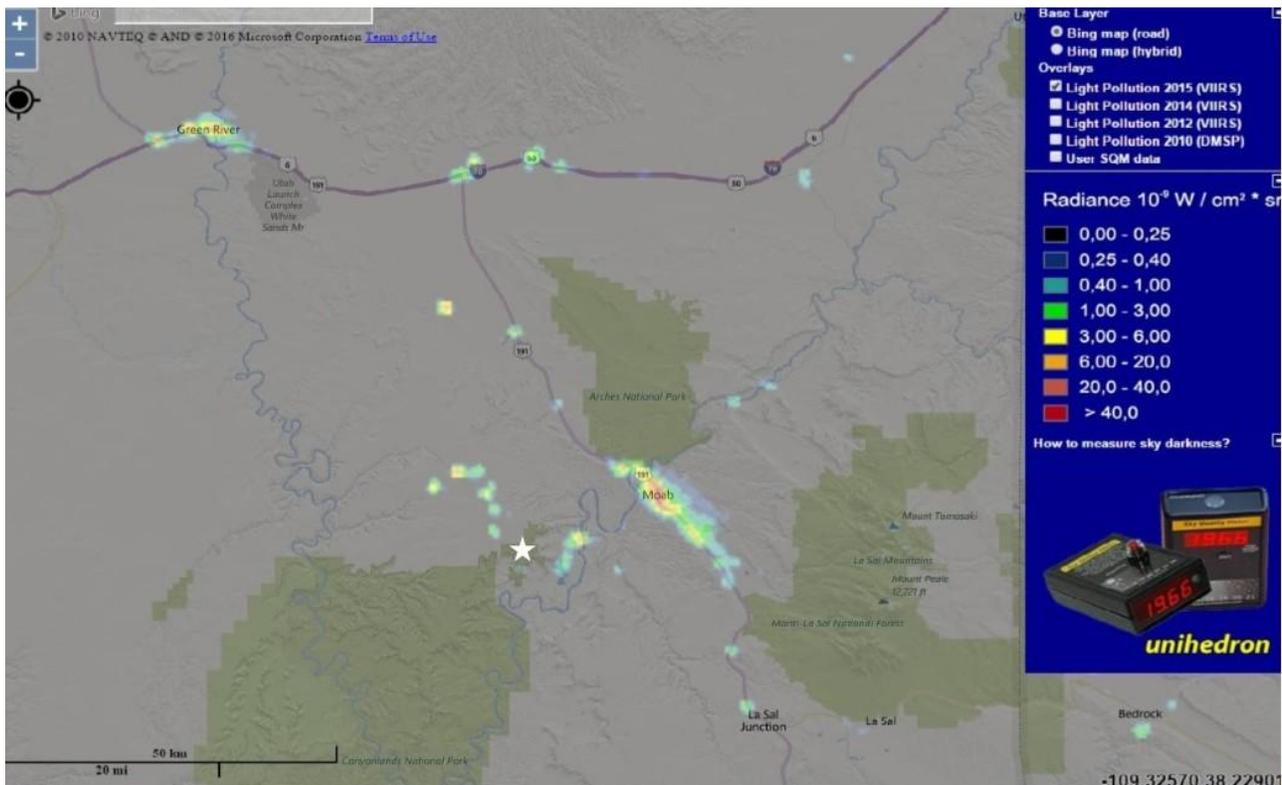
Example from Air Atlas 2005-2009 displaying the 4th highest annual value of the maximum daily 8-hour ozone concentration in parts per billion.

Isolation from Light Pollution

Light pollution limits the visibility of the Milky Way to the unaided eye, the visibility of nebulae and galaxies seen in telescopes, and raises the noise on CCD astrophotography. Only the observation of planets and double stars is unaffected. Dark skies, are one of the most important properties of a good astronomical observing site.

This map is a small excerpt (362mi east-to-west, by 346mi north-to-south) from the Light Pollution Atlas 2006 by David Lorenz. David recalculated the The World Atlas of the Artificial Night Sky Brightness with newer data.

The white star marks the location of the Dead Horse Point clear sky chart. An observer at Dead Horse Point State Park should see a slightly darker sky.



(<http://www.lightpollutionmap.info>)

Note: Light pollution showing within the park boundaries is from 7 lights on the campground bathroom and the visitor center which have already been changed from a 150w bulb to an amber 7w LED bulb



Dead Horse Point State Park is isolated from cities and towns of any significant size. The park and its immediate environs produce very little light pollution of their own, with only minimal measurable amounts from certain parts of the park.

Additional measurements of Dead Horse Point State Park's dark skies were taken throughout the park. A Unihedron Sky Quality Meter was used to take measurements at 7 locations around the park, ranging from the areas with the most light pollution influence from local communities, to those facing essential wilderness.

Average SQM (Zenith) for Dead Horse Point State Park: 21.59

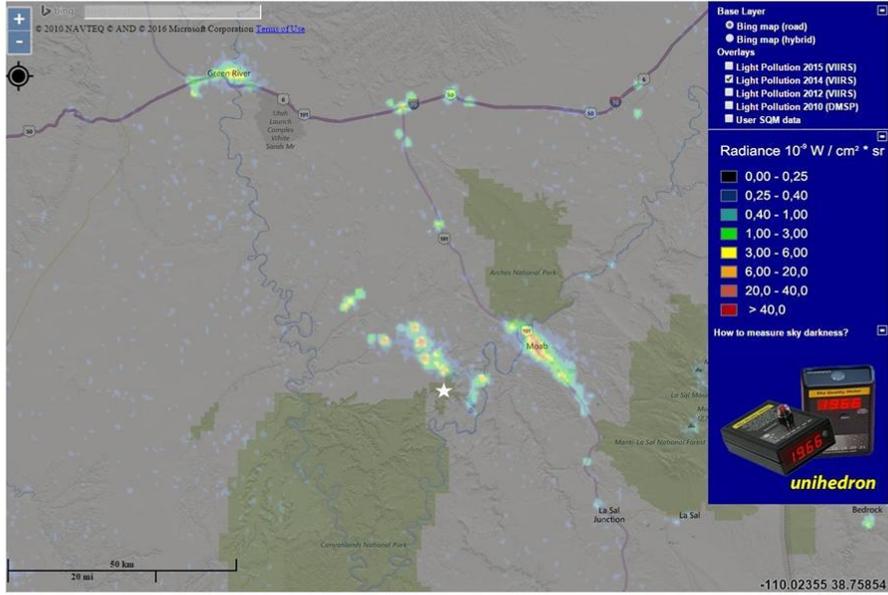
As stated, the main sources of light pollution in the park are the surrounding towns of Green River, Moab, Intrepid Potash Mine, oil wells and Monticello.

Park Leadership Project

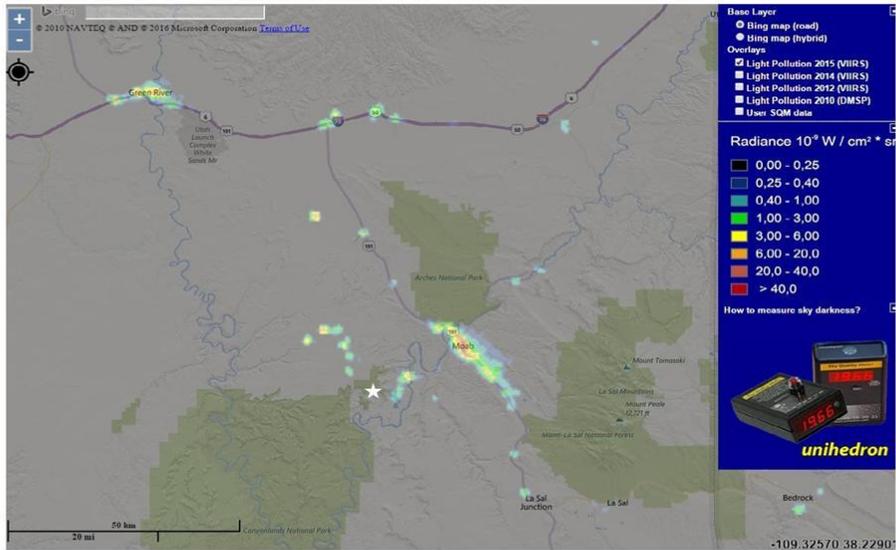
Night sky quality is most impacted by the development of oil rigs on Bureau of Land Management land located outside the park. The Park's resource management team has spoken with a company representative from Fidelity about the quest to become an international dark sky park and the impact the well lights have on the natural darkness of the area, as well as resident wildlife. There was a request to limit light as much as possible and only use it when necessary. Within one month, Fidelity began limiting the light emitted from the wells in Big Flat reducing light trespass into the Park. In the past six months, the lights have been used only as needed, limiting their impact on Dead Horse Point State Park's and Canyonlands National Park's night skies. The following light pollution maps show the difference in lighting before working with the company that owns the oil wells and after.

The Resource Manager for Dead Horse Point State Park in cooperation with Nate Ament, has approached Moab City Mayor to begin discussions on creating a lighting ordinance for new construction. A meeting is set up for this March and includes representatives from Grand County as well.

Dead Horse Point State Park's light pollution in 2014



Dead Horse Point State Park's light pollution in 2015



NPS Night Skies Program Data Night Report Explanation

D Duriscoe
February 2015

Introduction

This document provides a quick explanation of so-called "Data Night Reports" generated automatically from the Night Skies Program master database. A brief description of each table, and each attribute reported within them, is included. For the theoretical basis and methods of computation the reader is referred to a more complete document (Duriscoe 2015).

A "Data Night" is an unique combination of date and location representing when and where sky brightness data was collected. The Night Skies Program uses a code, usually a combination of 4 letters and 6 numbers, that describes the park or other area and date. The date is defined at the start of data collection in Universal Time (UT). Hence it is often one day later than Local Time, either Standard, Daylight, or Local Mean Time (LMT), for locations in North America if data collection is begun in the evening. A "Data Set" is one complete set of 45 images that cover the entire sky. Multiple data sets are often taken over the course of the night to detect changes in artificial sky glow from evening to early morning.

The NPS Night Skies Program Data Night Report contains three main sections: 1) general attributes of the data night and each data set, 2) a list of populated places that may contribute to sky glow observed, and 3) the sky brightness and estimated artificial sky glow mosaics for each data set, illustrated in false color in panoramic equal-area projection, with a table of derived statistics and indicators of the impact of light pollution. The report provides a "snapshot" of the photic environment at the time of the observations as well as an estimate of the impact from artificial sources.

Photometric units of measure used include *SI* units of luminance (candela per square meter) and illuminance (lux), as well as astronomical units of luminance (magnitudes per square arc second) and illuminance (magnitudes) in the V, or visual, band. *SI* units are linear, astronomical units are inverse logarithmic, that is, smaller values indicate brighter objects, and negative values are possible.

Page 1. Metadata and visual observations

First line: Data Night Code, Park or other area, Location name, and Date (UT)

Data Night Attributes Table

Longitude: Longitude in decimal degrees (west is negative), Datum WGS 84, taken with GPS receiver, typical horizontal positional accuracy 5 meters

Latitude: Latitude in decimal degrees (north is positive), Datum WGS 84, taken with GPS receiver, typical horizontal positional accuracy 5 meters

Elevation (m): Elevation above mean sea level in meters, taken with GPS receiver, typical vertical positional accuracy 15 meters

Camera: Short description of the camera used. The camera name is usually the manufacturer, such as SBIG (Santa Barbara Instruments Group), followed by a number separating multiple cameras used with the same manufacturer.

of sets: A count of the number of individual data sets collected over the night at this location.

Exposure (secs): Exposure (or integration) time of each image in seconds.

Air Temp (C): Air temperature at start of image acquisition as measured by a portable weather meter in degrees Celsius. Typical accuracy is 3 degrees.

R.H. (%): Relative humidity at start of image acquisition as measured by a portable weather meter. Typical accuracy is 5%.

Wind Speed (mph): Average wind speed at the start of image acquisition as measured by a portable weather meter held at eye level. Typical accuracy is 3 mph.

ZLM: Zenith limiting magnitude, or the faintest stars than can be observed visually without optical aid (naked eye) near the zenith, or darkest part of the sky. This observation varies somewhat from observer to observer, but all observers are instructed to practice the same methods. 6.6 is considered near pristine under average conditions. 7.0 is achievable under good seeing conditions and with proper dark adaptation of the eye. 7.4 is excellent, just about the faintest attainable, although some observers have confirmed seeing stars as faint as magnitude 8.2 with the naked eye. A number lower than 6.3 usually indicates significantly degraded sky quality.

BORTLE: A semi-quantitative measure of the sky quality observed visually, as developed by astronomer John Bortle. Classes are whole numbers 1-9, with 1 the very best and 9 the poorest.

SQM: A measurement taken with the Unihedron Sky Quality Meter, in magnitudes per square arc-second (mag arcsec⁻²), aimed at the zenith.

OBS-1, OBS_2, OBS_3: Name(s) of the observer(s).

NARRATIVE: A descriptive narrative of the conditions observed visually during the night of data collection. This usually includes seeing (a measure of atmospheric steadiness), and transparency (a measure of atmospheric clarity) in semi-quantitative terms. Also may include characteristics of the site, the appearance of certain astronomical features, and the suitability of the site for visual astronomy by park visitors.

Data Set Attributes Table

Data Set: Data set number

Quality Flags: *Useable*--Y or N (yes or no), a determination as to whether or not the data should be included or rejected based upon inspection of the mosaic; *Collection*--(1-5, 1 poorest, 5 best) a semi-quantitative judgment as to the quality of data collection, including such factors as camera and mount performance, accuracy of mount setup, presence of stray light; *Processing*--(1-5, 1 poorest, 5 best) a

semi-quantitative judgment as to the quality of data processing, including image calibration, atmospheric extinction calculation, instrument zeropoint calculation; *Atmosphere*—(1-5, 1 poorest, 5 best) a semi-quantitative judgment as to the quality of atmospheric conditions, where excellent transparency and steadiness, low relative humidity, and the complete absence of clouds or smoke plumes is best.

Natural Sky Model: A report of the amount of natural *airglow* used at the *zenith* in micro-candela per meter squared ($\mu\text{cd m}^{-2}$), the *Fit Quality* of the model (1-5, 1 poorest, 5 best), a semi-quantitative judgment as to the quality of natural sky model fit based upon inspection of the artificial sky glow mosaic as compared to the natural sky model mosaic, and *Natural sky model fit notes*, which explain why the operator assigned the zenith airglow intensity and fit quality reported.

Extinction: A report of calculated all-sky atmospheric extinction for each data set. Extinction is a measure of the opacity of the air, the units are astronomical magnitudes per airmass. Airmass depends on its zenith angle and the relationship is not linear. A star viewed at the exact zenith is by definition view through one airmass. This value is computed for each data set from measurements of 50-150 standard stars on the images over the entire sky.

Attributes reported in the table include: *Extinction coefficient* in V magnitudes per airmass, *Standard error of Y*, in V magnitudes, a measure of the fit of the observed data to a regression line (0.03 or smaller is excellent while 0.06 and larger is poor), and the *Number of reference Stars used and rejected* in the regression equation. Rejected stars are outliers of greater than 0.1 magnitude, presumably because they were partially masked by horizon obstructions or clouds, measured incorrectly because of scintillation, or measured incorrectly because of within-pixel variations in the sensitivity of the CCD detector.

Collection Properties: A report of the observed *percentage of clouds* in the entire sky, the *Average Pointing Error* of the camera mount system in degrees (less than 0.25 is excellent, more than 0.5 is poor), the *Maximum Pointing Error* of the camera mount system in degrees (less than 0.4 is excellent, more than 1.0 is poor), and the *total bias drift* of the camera over the course of the 45 images in each data set in raw camera ADUs (more than 10 ADU drift may indicate a camera problem).

Page 2(-3). Populated Places Table

A table of places within 300 km of the observing site is displayed ordered with decreasing potential to produce artificial sky glow. The places name (*Place*) and *Population* are given from the 2010 U.S. Census. The *Distance* in kilometers, apparent *Azimuth*, and *Apparent Half-Width* in degrees as seen from the observer's location are given based upon the longitude and latitude of the place's centroid and assuming a circular area whose diameter is computed based upon the land area of the populated place given in the Census database. Finally, each place is ordered according to *Walker's Law*, a formula which predicts sky glow intensity of a populated place as a function of its population and distance from the observer. The numbers shown in the table for this attribute are a unitless ratio with linear scaling. An arbitrary cutoff is made for the lower limit of this value that includes a reasonable number of populated places (less than 50).

Pages 3(4) +. All-sky Photometry Report

The all-sky photometry report is scaled so that one data set fits on one page, and multiple data sets are reported on succeeding pages.

First Line: The *Data Night Code*, the *Date* in Local Mean Time (LMT), the *Time* of the middle of image collection in LMT in decimal hours, whether or not (Y or N) the data set is the *Reference* set for the night,

and the *Data Set Number*. Local Mean Time is used for comparison between locations and data nights, with local midnight being 0.0 hours. Local midnight is the time when the sun is at its maximum position below the horizon.

First Figure – Full Resolution Mosaic

The full resolution mosaic of the data set's images rendered in false color. Each individual image is placed in the mosaic after correction for pointing errors, and projected into a Hammer-Aitoff equal area projection with the horizon at the center vertically and a fixed azimuth at the center horizontally. The false color scheme reveals a wide dynamic range of sky brightness values in a logarithmic scale from 14 to 23 mag arcsec⁻². The all-sky image mosaic (zenith to 6 degrees below the level horizon) contains about 34 million pixels. Land features and individual light trespass sources are often visible in this rendering.

Photometry of all sources Table

A table of summary measures from the sky brightness mosaic is given. The sky brightness mosaic is derived from the full resolution mosaic by applying a strong median filter to screen out stars, then resampling to 0.05 degrees per pixel resolution, for a total of about 8 million pixels covering the entire sky in an equal-area projection. Bright unshielded lights in the land portion of the mosaic will not be accurately measured for two reasons: they commonly are so bright their recorded luminance exceeds the dynamic range of the detector so they become clipped or saturated at the maximum ADU value, and the median filter will remove most of the light from these sources since they resemble stars or point sources. Therefore "all sources" should not be interpreted to include accurate measures of light trespass from visible individual lights, even if they appear in the full resolution mosaic. Very bright sources such as this will often cause vertical lines or "column bleeds" in the full resolution image; these are removed by the median filter technique before statistics are calculated. A graphic of the sky brightness mosaic is not shown in the report.

Average Sky Luminance is an important statistic describing the photic environment. It is reported in logarithmic units of mag arcsec⁻² and linear units $\mu\text{cd m}^{-2}$. The natural moonless reference condition is set at 21.6 mag arcsec⁻² or 250 $\mu\text{cd m}^{-2}$. This is an unbiased measure of the amount of light reaching the observer from sky luminance.

Zenith Luminance is often reported as a sky quality indicator in the astronomical literature. This measure is calculated from the median pixel value of an approximately one degree diameter circle centered on the zenith. 22.0 mag arcsec⁻² or 172 $\mu\text{cd m}^{-2}$ is generally considered to represent the darkest part of pristine skies, any value lower (brighter) than 21.3 mag arcsec⁻² usually indicates significantly degraded sky quality, unless the measurement falls in the Milky Way, the natural airglow, or bright portions of the Zodiacal Light.

Brightest Luminance is an important value because the human eye's ability to dark adapt will be impaired by the brightest part of the visual scene, and because bright parts of the sky may cast shadows from 3D objects on the land surface, giving depth to an otherwise uniformly lit natural landscape. The brightest part of the Milky Way is 19.6 mag arcsec⁻² or 1500 $\mu\text{cd m}^{-2}$. Brighter values will begin to impair dark adaptation, values brighter than 17.0 mag arcsec⁻² can cast shadows.

The *Synthetic SQM* value is given for comparison to a measure with the Unihedron Sky Quality Meter. It is considered to be more accurate than the actual measure, since it is computed from the sky brightness mosaic based upon accurate alignment to zenith and accurately calibrated CCD camera data. The sky

brightness values in the data set are subjected to an algorithm that matches the SQM response curve with zenith angle. The units are mag arcsec⁻². Values of 21.3 and greater (darker) fall within the range of "natural" skies (Bortle Class 1-3), 19.5-21.3 may be considered significantly degraded skies (Bortle Class 4-6), while values less than 19.5 may be considered severely degraded (Bortle Class 7-9). The SQM is only sensitive to areas of the sky 30 degrees above the horizon and higher, so will not measure bright sources of artificial sky glow along the horizon.

Total luminous emittance exactly correlates with average sky luminance, but in units of illuminance. It represents the total luminous flux from the sky if all the light were collected into a point or source of small angular diameter, like the moon. This summary value excludes the light from individual stars and planets and glare from unshielded lights but includes the Milky Way, Airglow, Zodiacal Light, and artificial sky glow. When expressed in astronomical magnitudes it can be compared with the moon at various phases (-8 at crescent, -11 at half phase, and -12.5 at full phase). A value larger (darker) than -7.0 is exceptionally dark; between -7.5 and -7.0 is typical for near pristine locations. A value smaller (brighter) than -8.0 usually indicates significantly degraded sky quality.

Horizontal and Maximum Vertical Illuminance are important measures of the amount of light striking the ground (horizontal) or a vertical plane (vertical). The units are milli-lux (mlux). The natural reference condition for moonless nights is 0.8 mlux for horizontal and 0.4 mlux for vertical. The maximum vertical illuminance is for a plane facing the brightest part of the sky near the horizon.

Second Figure – Estimated Artificial Sky Glow

The sky glow mosaic is the sky brightness mosaic subjected to pixel by pixel subtraction of a registered natural sky model mosaic (the natural sky model is not shown as a graphic in the report) rendered in the same false color scale as the full resolution mosaic. The resolution is 0.05 degrees per pixel. Land features and individual light trespass sources are masked out so that only sky luminance from artificial sky glow is shown. This is an at-a-glance representation of the amount of light pollution from sky glow observed at the site. Artificial sky glow will always be brighter near the horizon than at the zenith and its impact on the natural lightscape substantial.

Photometry of Artificial Sky Glow Table

This table includes indicators of sky quality based upon the estimated artificial sky glow mosaic in absolute, relative, and index units.

The *Sky Quality Index* is a synthetic index derived from the distribution of sky luminance values in the artificial sky glow mosaic. Its range is 0-100, where 100 is a sky free of artificial sky glow. Values of 80-100 may be considered to represent skies that retain all of the natural characteristics throughout most of the sky, 60-80 retaining most of the natural sky features, but only in areas within 40 degrees of the zenith, 40-60 represents skies where the Milky Way is not visible or only the brightest parts are visible near the zenith, 20-40 represents skies only stars and planets remaining and the land is illuminated at a level of moonlight, and 0-20 indicates only the brightest stars remain, and the land is in perpetual twilight.

The *Average Sky Luminance*, *Zenith Luminance*, and the *Brightest Luminance* are reported as in the all sources table, but in linear units only. The whole sky mosaic is clipped at 80 degrees zenith angle and 70 degrees and an average sky luminance computed for each in order to provide a more unbiased comparison to areas that may have blocked horizons.

The *All-sky Light Pollution Ratio* (ALR) is the most important indicator of light pollution from artificial sky glow. It is merely the ratio of the all-sky average luminance from artificial sources to the natural reference condition of $250 \mu\text{cd m}^{-2}$. This unit-less ratio may be easily interpreted as a linear measure of the amount of light from sky brightness above the natural background. For example an ALR of 1.0 indicates there is 100% more light in the environment than natural conditions, 2.0 = 200%, 0.5 = 50%, etc.

The *Total Luminous Emittance* from artificial sky glow expressed in magnitudes may be compared to astronomical objects such as Sirius or Jupiter (-2), Venus (-4), a thin crescent moon (-7), or the moon at other phases as described above.

Horizontal and *Maximum Vertical Illuminance* are reported as in the all sources table. These values may also be compared to the reference condition of 0.8 mlux and 0.4 mlux, respectively.

References

Duriscoe, D.M. (in preparation) Assessing night sky quality with all-sky broadband photometric imaging. NRSS, Fort Collins, CO.

NPS NIGHT SKIES PROGRAM DATA NIGHT REPORT

DHSP150619

Dead Horse Point SP

Dead Horse Point

19-Jun-15



Data Night Attributes

Longitude:	-109.73988	Camera:	ML 3	Air temp. (C):	25.7	ZLM:	7.10	OBS_1:	B Meadows
Latitude:	38.46919	# of sets:	2	R. H. (%):	12.4	BORTLE:	2	OBS_2:	
Elevation (m):	1818	Exposure (secs):	14	Wind Speed (mph):	1	SQM:	21.59	OBS_3:	

NARRATIVE: Light dome of Grand Junction and Moab extend up to about 15 degrees. Salt Lake City barely visible. Visibility earlier in the evening was fairly good. Could see to Boulder Mountain and Aquarius Plateau to the west of the Henry Mountains. There was a fair amount of haze towards the horizon. The LaSal Mountains clear to the east. Milky Way prominent with good detail in Sagittarius star cloud. Venus very bright on the low horizon in the west. Even with Moab close by, a very nice location for night sky observations.

Data Set Attributes

Data Set	Quality Flags				Natural Sky Model			Extinction				Collection Properties			
	Use-able	Col-lection	Pro-cessing	Atmo-sphere:	Zenith airglow ($\mu\text{cd}/\text{m}^2$)	Fit quality	Natural sky model fit notes	Ext. coeff. (mag/airmass)	Std err Y	# stars used	# stars reject	% Clouds	Ave. Point Error	Max Point Error	total bias drift
1	Y	5	5	4	127	4	Very strong airglow, but pretty good subtraction	0.167	0.03	148	1	2	0.30	0.49	2.7
2	Y	5	5	4	124	4	Very strong airglow, but pretty good subtraction	0.171	0.03	132	1	2	0.33	0.51	1.9

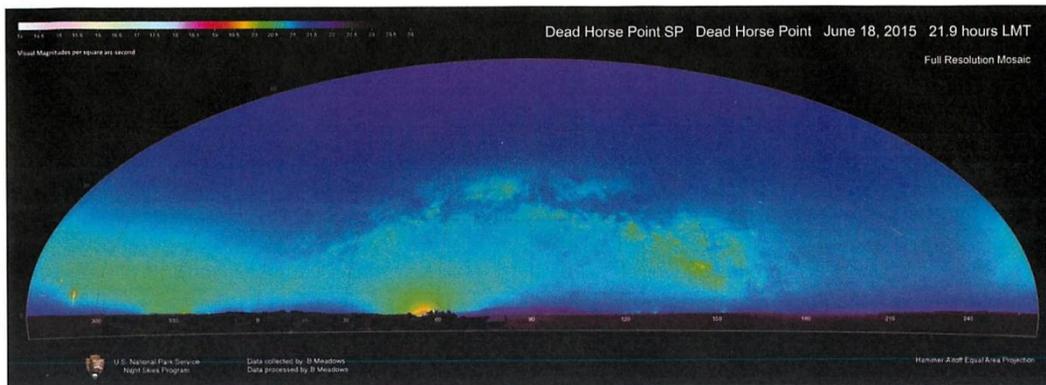
Populated Places

Place	Population (2010)	Distance (km)	Azimuth	Walker's	Apparent Half-Width (degrees)
Moab city	5,046	20.1	54	0.277	5.2
Grand Junction city	58,566	122.5	56	0.035	2.6
Denver city	600,158	442.8	70	0.015	1.5
Spanish Valley CDP	491	27.7	89	0.012	7.0
Provo city	112,488	256.4	321	0.011	1.3
Colorado Springs city	416,427	434.2	83	0.011	1.7
Clifton CDP	19,889	129.8	58	0.010	1.0
Salt Lake City city	186,440	317.8	325	0.010	1.7
Fruita city	12,646	116.1	49	0.009	1.2
Orem city	88,328	263.9	321	0.008	0.8
West Valley City city	129,480	314.1	322	0.007	1.0
West Jordan city	103,712	306.1	321	0.006	1.0
Redlands CDP	8,685	116.1	54	0.006	1.6
Sandy city	87,461	295.6	323	0.006	0.8
Montrose city	19,132	163.5	89	0.006	1.3
Farmington city	45,877	234.8	144	0.005	1.2
Castle Valley town	319	34.9	58	0.004	4.2
Orchard Mesa CDP	6,836	123.0	59	0.004	0.8
Fruitvale CDP	7,675	129.4	57	0.004	0.7
Monticello city	1,972	75.2	153	0.004	1.5
Lakewood city	142,980	421.4	70	0.004	0.8
Millcreek CDP	62,139	304.6	325	0.004	0.6
Blanding city	3,375	96.1	168	0.004	2.0
Spanish Fork city	34,691	244.5	319	0.004	0.8
Taylorsville city	58,652	308.1	323	0.004	0.6
Lehi city	47,407	283.7	320	0.003	0.9
Ogden city	82,825	360.6	329	0.003	0.8
Delta city	8,915	147.9	77	0.003	1.3
South Jordan city	50,418	300.9	321	0.003	0.8
Springville city	29,466	248.2	320	0.003	0.8
Layton city	67,311	346.3	328	0.003	0.7

DHSP150619

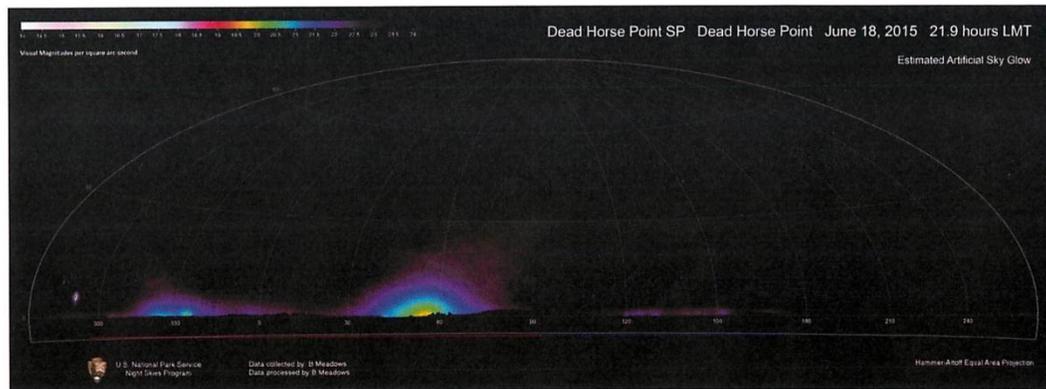
Date (LMT) 18-Jun-15

Time (LMT): 21.87



PHOTOMETRY OF ALL SOURCES

Average Sky Luminance (mag arcsec ⁻²)	Average Sky Luminance (μcd/m ²)	Zenith Luminance (mag arcsec ⁻²)	Zenith Luminance (μcd/m ²)	Brightest luminance (mag arcsec ⁻²)	Brightest luminance	Synthetic SQM (mag arcsec ⁻²)	Total luminous emittance (mags)	Illuminance (mlux) Horizontal	Illuminance (mlux) Max Vert
21.18	364	21.80	207	18.50	4,304	21.52	-7.39	0.990	0.665



PHOTOMETRY OF ARTIFICIAL SKYGLOW

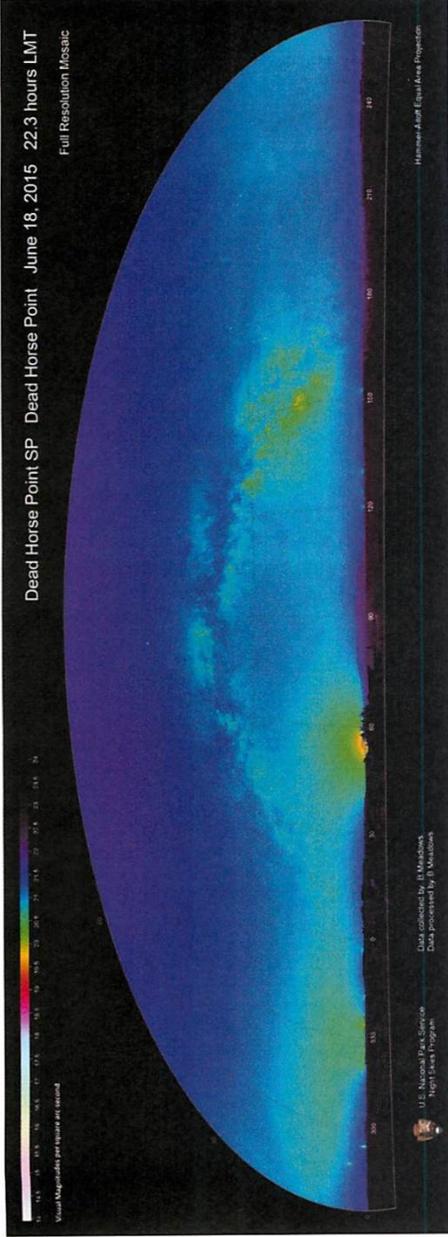
Sky Quality Index (SQI)	Average Sky Luminance (μcd/m ²)	Average Sky Luminance to zenith angle 80°	Average Sky Luminance to zenith angle 70°	Zenith Luminance	Brightest luminance (μcd/m ²)	All-sky light pollution ratio (ALR)	Total luminous emittance (mags)	Illuminance (mlux) Horizontal	Illuminance (mlux) Max Vert
97.0	6	-0.7	1.5	1	3,733	0.02	-2.94	0.005	0.068

DHSP150619

Date (LMT) 18-Jun-15

Time (LMT): 22.30

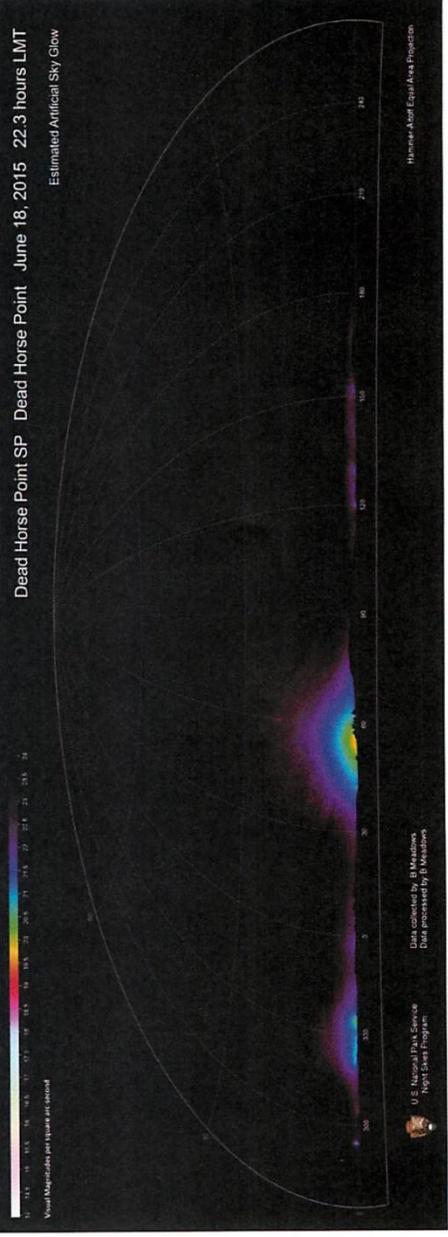
Dead Horse Point SP Dead Horse Point June 18, 2015 22.3 hours LMT
Full Resolution Mosaic



PHOTOMETRY OF ALL SOURCES

Average Sky Luminance (mag arcsec ⁻²)	Average Sky Luminance (μcd/m ²)	Zenith Luminance (mag arcsec ⁻²)	Zenith Luminance (μcd/m ²)	Brightest luminance (mag arcsec ⁻²)	Brightest luminance (μcd/m ²)	Synthetic SQM (mag arcsec ⁻²)	Total luminous emittance (mags)	illuminance (milux) Horizontal	illuminance (milux) Max Vert
21.19	361	21.83	200	19.46	1,785	21.51	-7.38	0.990	0.656

Estimated Artificial Sky Glow



PHOTOMETRY OF ARTIFICIAL SKYGLOW

Sky Quality Index (SQI)	Average Sky Luminance (μcd/m ²)	Average Sky Luminance to zenith angle 80°	Average Sky Luminance to zenith angle 70°	Zenith Luminance	Brightest luminance (μcd/m ²)	All-sky light pollution ratio (ALR)	Total luminous emittance (mags)	illuminance (milux) Horizontal	illuminance (milux) Max Vert
97.1	13	6.5	8.1	-3	1,598	0.05	-3.73	0.022	0.067

Visitor Experience

Night Sky Interpretation at Dead Horse Point State Park

The solitude, remoteness, and arid landscapes of Dead Horse Point State Park make it an ideal place for stargazers, amateur astronomers, and astrophotographers. The park is dedicated to enhancing these experiences for visitors, using interpretation and public education to increase awareness and heighten visitor connection to the night sky. Interpretive staff at Dead Horse Point State Park receives night sky training alongside of national park employees, and has partnered with local national parks to help promote dark sky awareness. The park is also allows for 24/7/365 unrestricted access within the day use areas for astrophotographers and night sky viewing.

Night sky interpretation at Dead Horse Point State Park includes:

- Monthly star programs during the new moon where an interpretive talk, constellation tour, and telescope viewing connect visitors to this valuable resource.
- Programs are produced in collaboration with Canyonlands and Arches National parks, and alternate between all three sites.
- Interpretive talks and pinhole camera viewings during the solar eclipse of 2014.
- A poster displayed in the campground discussing dark skies, management commitment to preserving natural darkness and prevention of light pollution within the park.
- Brochure with the same information as the poster for those seeking more information plus things visitors can do to help reduce the impact of light pollution within the park and at home.
- Full moon programs, with special programming based around the lunar eclipses of 2015.

CELEBRATE THE STARS

Join rangers from Dead Horse Point State Park and Canyonlands National Park as we explore our night skies. A short interpretive program will be followed by telescope viewing. Programs will take place in good weather or bad. Bring a chair, a red flashlight (if you have one), and warm clothes.

March 29 -- Dead Horse Point Visitor Center, 7:30 pm
April 26 -- Island in the Sky Visitor Center, 8:30 pm
May 31 -- Dead Horse Point Visitor Center, 9 pm
August 23 -- Island in the Sky Visitor Center, 8:30 pm
September 27 -- Dead Horse Point Visitor Center, 7:30 pm
October 25 -- Island in the Sky Visitor Center, 7 pm

We look forward to seeing you!

The poster features a map of the area showing Dead Horse Point State Park and Canyonlands National Park. It also includes logos for Utah DNR and Colorado Plateau Dark Sky Cooperative.

Community Outreach

Each year, our night sky ranger donates a night sky experience outing to Moab's Seek Haven Family Crisis and Resource Center's annual silent auction. In 2013, 2014 and 2015, this outing resulted in a donation of \$200 and has been extremely popular. Our night sky ranger did receive this response from last year's auction winners after attending the program.

"Crystal,

Thanks so much! Although we could have asked for better weather (no clouds), we couldn't have asked for a better presenter. Thanks so much! We all had a great time. Kaci (my friend Jeri's oldest) was the one who was so excited it was like having butterflies in her tummy. My grandkids enjoyed the presentation; but, were equally thrilled that the clouds meant that it was going to snow. I loved presentations such as yours because they are so informative; you are such a great teacher/presenter. Each answer that was given to one of your queries was listened to with respect, validated, and guided to a correct response. You made us all feel intelligent and the love that you have for the subject matter was evident. Thanks again.

Happy New Year!"

Joanne

An Evening Under the Stars Dead Horse Point State Park



Learn more about the current astronomical events, learn to identify the current night sky constellations, and view deep space objects through the park's telescope. Crystal Carpenter, a naturalist of 12 years, will guide a 3-hour program for your group.

This offer is valid through 2015, expiration date is January 1, 2016. Valid for up to 10 people. Bid winner will receive instructions. No entrance fee for the park.

Approximate value estimated at \$200.

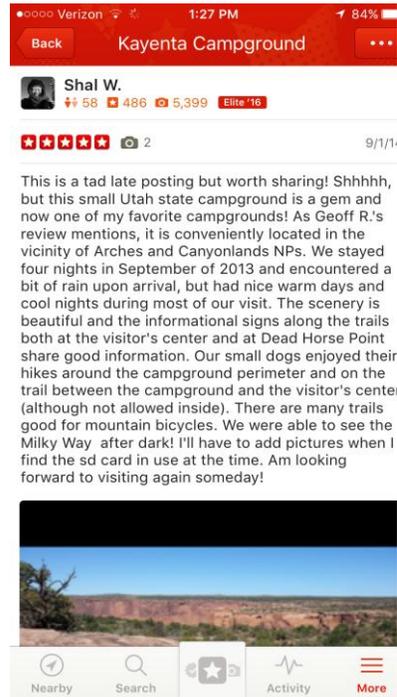
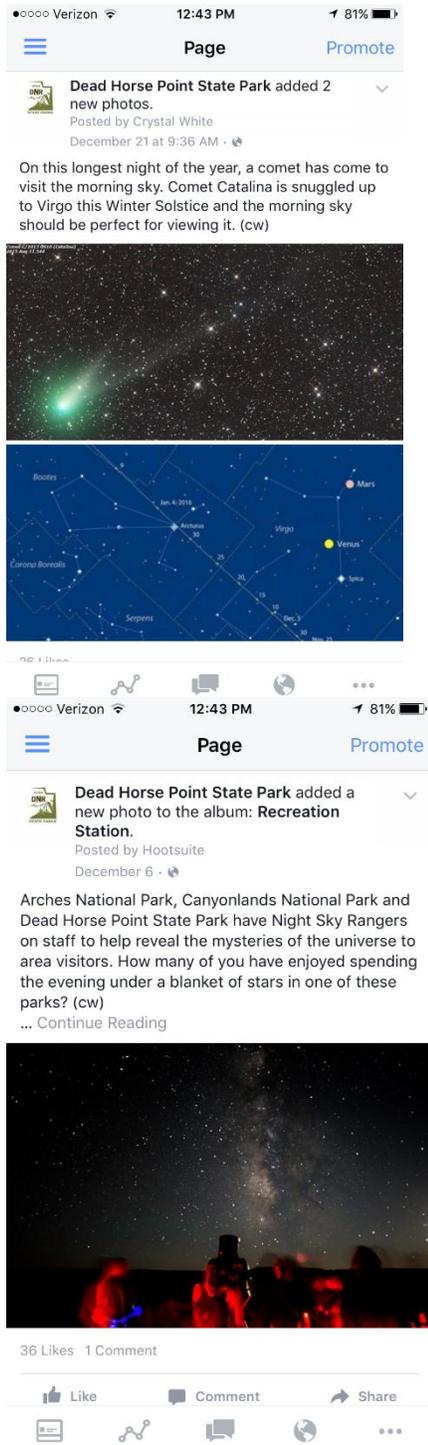


Dead Horse Point State Park is also a member of the Colorado Plateau Dark Sky Cooperative. This Cooperative consists of various National Parks, National Monuments, private land owners, and State Parks who have pledged their commitment to protect the natural darkness found within the land they manage and to assist local communities with education for best night sky friendly lighting practices.

Our night sky ranger, Crystal White is also working with Nate Ament of the NPS Night Skies Team and the Moab City Council to begin a discussion on lighting regulations for new construction and incentives to retrofit lights to be night sky friendly for Moab residents. Our first meeting will be during the winter of 2015-2016.

Social Media Outreach

Our night sky ranger often creates social media posts highlighting the park's natural darkness resource and opportunities open to area visitors for experiencing the park at night.



Public Lighting Project

With an increase of exterior lighting being built in to many RVs, Trailers and Campers, we began to notice quite a bit of light trespass happening within the Kayenta campground. Management staff tried to figure out how to approach the situation for campground users that were being affected by the light trespass. Staff settled on a creation of the following brochure which would be handed out to each camper as they check-in for their campsite. It is also available at the visitor center for anyone curious about the night sky, our commitment to preserving the natural darkness within the park, and suggestions for visitors to help reduce light trespass while visiting the park. The brochure is also hanging on the campground, yurt and visitor center bulletin boards, so that all who visit can read it.

How You Can Help

Preserve Natural Darkness

While camping or staying in the yurts at Dead Horse Point State Park, there are a few simple things you can do to help protect the natural darkness found within the park. These are really simple actions that can hold a huge benefit for fellow campers, wildlife and plants.

- 1) Use light only when you need it. If you are not hanging out outside, please turn off the exterior lights on all trailers, RV's, in table shelters or within tents.
- 2) Use warmer colored lights of low wattage for exterior lighting. Red headlamps or amber colored exterior lights are much easier for wildlife and human eyes to adjust to. They will also not affect your night vision allowing you to go from cooking your dinner to viewing the stars above.
- 3) Attend a ranger guided night sky programs or full moon hikes. For current programming schedules, please stop in to the visitor center.
- 4) Only use the lights provide at the campsite for lighting within your site. Amber lighting is available within each table shelter.
- 5) Turn off lights within the yurts and outdoor pavilion when not in use.

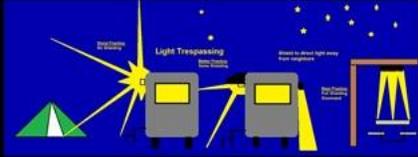
"In these countless stars, in their clusters and colors and constellations, in the "shooting" showers of blazing dust and ice, we have always found beauty. And in this beauty, the overwhelming size of the universe has seemed less ominous, earth's own beauty more incredible. If indeed the numbers and distances of the night sky are so large that they become nearly meaningless, then let us find the meaning under our feet."

— Paul Bogard, *The End of Night: Searching for Natural Darkness in an Age of Artificial Light*

Dead Horse Point State Park

"Stars can't shine without darkness."
—D.H. Sidebottom, *Fragile Truths*

In 2014, Dead Horse Point State Park made the commitment to preserve the natural darkness found within the park and to share this amazing resource with those who visit. During your visit to the park, we encourage you to spend an evening under the night sky. The views are stellar.





COLORADO PLATEAU
DARK SKY COOPERATIVE



UTAH
DNR
STATE PARKS



Continued on next page.

Becoming a Dark Sky Park

In order to be designated as an International dark sky park, Dead Horse Point State Park had to demonstrate the quality of the night sky found within the park. When looking at the quality of the night sky, the International Dark Sky Association uses the Bortel Scale.

THE BORTLE DARK-SKY SCALE	
CLASS 1	EXCELLENT DARK-SKY SITE No light pollution is visible. Zodiacal light, zodiacal band, gegenschein, airglow and M33 galaxy are visible. Scorpius and Sagittarius region of the Milky Way cast shadows.
CLASS 2	TYPICAL TRULY DARK SITE Zodiacal light, airglow, M33 and Messier globular clusters and the summer Milky Way are visible. Clouds appear as dark holes in the sky. Surrounding objects are barely visible except when silhouetted against the sky.
CLASS 3	RURAL SKY Luminous pollution is evident along the horizon. Clouds appear illuminated near the horizon but are dark overhead. The Milky Way and globular clusters like M4, M5, M15 and M22 are visible. Zodiacal light and M33 are weak and/or difficult to see and objects 20-30 feet away are vaguely visible.
CLASS 4	RURAL/SUBURBAN TRANSITION Sky glow is visible in several directions. Clouds are illuminated near light pollution sources but are still dark overhead. Zodiacal light, Milky Way, and M33 are still visible but with some limitations. Objects are clearly visible at a distance.
CLASS 5	SUBURBAN SKY Light sources are visible in all directions. Clouds appear brighter than the sky itself. Zodiacal light and the Milky Way are barely visible.
CLASS 6	BRIGHT SUBURBAN SKY Skies within 30 degrees of the horizon glow a grayish white and the clouds are fairly bright. Zodiacal light is no longer visible and the Milky Way is only visible near the zenith. M33 is not visible without binoculars and M31 is faintly visible to the naked eye.
CLASS 7	SUBURBAN/URBAN TRANSITION Strong light sources are visible in all directions. Sky background appears grayish white near and clouds are brilliantly lit. The Milky Way is nearly or totally invisible and M44 or M51 are still visible to the naked eye but lack detail. Bright Messier objects are faintly visible with moderate telescopes.
CLASS 8	CITY SKY The sky glows whitish gray or orange. M31 and M44 are barely visible on good nights. Only bright Messier objects are visible with a modest telescope. Stars forming familiar constellations are difficult to see or invisible.
CLASS 9	INNER-CITY SKY The entire sky is a single lit. Many stars making up constellations are invisible and constellations such as Eriacus and Pegasus are invisible. Pegasus is the only Messier object visible to the naked eye. Moon, planets and a few bright star clusters are the only noticeable extragalactic objects.

Dead Horse Point State Park rates as a class 2-3 site on the Bortel Scale. Zodiacal light, airglow, M33 galaxy, Messier globular clusters, and the summer Milky Way are visible throughout the park. Clouds on new moon nights appear as dark holes in the sky. The landscape surrounding the park appears as a black silhouette against the night sky.

Truly dark skies are becoming increasingly rare throughout the world as artificial light continues to fill the darkness of night. Why should we preserve natural darkness?

The Value of Natural Darkness

- Natural circadian rhythms for humans rely on the darkness of night to tell our bodies when to sleep and when to wake. Disruptions to these natural rhythms have been proven by the American Medical Association to lead to an increased risk of diseases such as diabetes, cancer and auto-immune.
- Nocturnal animals wake and feed when the sky becomes dark. If artificial lights shine throughout the night over their burrow, the response to forage will be lost.
- Night active insects navigate by using the moon as a fixed point. Artificial lights can wash out the moon and seem very much like the moon to these insects causing them to spiral around a light source until exhausted.
- Inspires artists, poets, astrophotographers, amateur astronomers, and writers.

Action taken to be Night Sky Friendly

• Park Management created a Exterior Lighting Management Plan.

• Many exterior lights found around buildings have new fixtures which are fully shielded placing light only where it is needed.

• Some exterior lights have been placed on motion sensors, solar sensors or timers.

• Many bulbs have been changed to low wattage amber LED bulbs. The amber color is least impactful to humans, animals and plants within the Park. LED bulbs help the park save money and are energy efficient.

• Resource Management Plan has been adjusted to include the night sky as a resource to be preserved and exterior lighting management to reduce light trespass for visitors, wildlife and plants.

• Management has committed to providing quality night sky programming, to educate visitors on various astronomical topics as well as ways to protect natural darkness.

• Some areas of the park have been dedicated as Natural Darkness Zones.

• A partnership between Arches National Park, Canyonlands National Park, and Dead Horse Point State Park was created in 2013 to provide training for night sky rangers, public night sky education, and programming.

Dead Horse Point State Park Exterior Lighting Management Plan

Introduction

The solitude, remoteness, and arid landscapes of Dead Horse Point State Park make it an ideal place for stargazers, amateur astronomers, and astrophotographers. The park is dedicated to enhancing these experiences for visitors, using interpretation and public education to increase awareness and heighten visitor connection to the night sky. Preservation of natural darkness is of utmost importance to management of the park in complying with the requirements to obtain/maintain the park's status as an International Dark Sky Park.

The purpose of this plan is to establish a guideline to be followed when considering upgrading current facilities exterior lighting, adding new facilities with exterior lighting or changing existing facilities exterior lighting. This plan will outline the best practices for ensuring the protection of the parks natural darkness, reducing impacts on the park's wildlife, while ensuring the safety of nighttime visitors and reducing the impact to visitor experiences.

Light Pollution

A natural lightscape is one that is free of light pollution. Light trespass is describe as the misuse of outdoor lighting, especially in a natural or protected environment such as a park. The term light pollution has commonly been used to emphasize the concept that artificial light in the naturally dark environment is indeed a pollutant with undesirable ecological consequences, not just a nuisance. There are many good reasons to eliminate light pollution in parks, including:

1. The preservation of natural lightscapes will maintain the nocturnal environment within the range of natural variability. Excursions outside this natural range may result in a modification to natural ecosystem function, especially to systems involving the behavior and survival of nocturnal animals. The natural night sky is therefore one of the physical resources under which natural ecosystems have evolved.
2. The scenery of the park areas does not just include the daytime hours. A natural starry sky absent of artificial light is a key scenic resource, especially large wilderness parks remote from major cities (i.e. DHPSP).
3. The history and culture of many civilizations are steeped in interpretations of night sky observations, whether for scientific, religious, or time-keeping purposes. As such, the natural night sky is an important cultural resource, especially in areas where evidence of indigenous cultures is present.
4. The recreational value of dark night skies is important to campers and astrophotographers, allowing the experience of enjoying the night sky or sleeping under the stars.
5. Night sky quality is an important wilderness value, contributing to the ability to experience a feeling of solitude in a landscape free from signs of human occupation and technology.

Exterior Lighting Plan for Dead Horse Point State Park

Guiding Principles

All exterior lighting within Dead Horse Point State Park will be designed to preserve the natural darkness as much as possible and eliminate light trespass. Light will be used on an as-needed basis. Lighting color and luminosity will be decided by safety considerations for staff and park visitors while minimizing the impacts of artificial light on the natural lightscape, wildlife and night sky viewing. When a light is deemed necessary, if possible the light will be placed on a motion sensor or timer.

When considering exterior lighting the following questions should be asked. Is the light needed for safety of staff or visitors? Is the light needed all the time or can it be activated as needed? What luminosity is appropriate for this area?

Lighting Guidelines

- 1) All lighting installations will be placed only where they are needed for safety considerations.
- 2) If safety considerations allow for a motion sensor or timer to be applied to limit the duration of artificial light, one should be in place.
- 3) All lights will be fully shielded and pointing down with the exception of the traffic lights at the entrance station and the flag light at the entrance station (which is to remain fully shielded) and the fee sign light. The fee sign light will be fully shielded however will shine at an upright angle. The luminosity of the bulb should be such that it does not shine beyond the sign boundary.
- 4) The use of white or blue lights will be limited to areas with major safety consideration. If blue or white lights are used, they shall not exceed 4000K in day use areas or 2700K in areas with active wildlife habitation nearby. If this type of light is to be used within the emergency lights (plumbing emergencies that may go into the night to fix) around the visitor center, the luminosity should be limited to emergency lighting and only what is and should not be used in environmentally sensitive locations (e.g. campground, yurt site, fee station, residences, shop or Dead Horse Point). All other locations will have amber bulbs to limit the effect on wildlife and human circadian rhythms. Dead Horse Point shall remain without lighting of any kind.
- 5) All bulb luminescence will be chosen based on need according to area hazards or specific needs. Amber LED bulbs with 2 wattage (1800K 200 lumens), or 7 wattage (120V 2000K 395 lumens) is preferred over all others.
- 6) The Visitor Center Emergency Lights are only to be used during emergencies will be 17 watt (3000 K 1250 lumens), but must be only used during emergencies and are not to be left on when not needed. This is the only location where blue/white lights shall be used.
- 7) Use the minimum amount of light necessary.
- 8) Select the most energy efficient lamp and fixture
- 9) The lighting management plan shall conform to or surpass applicable policy in the Grand and San Juan county jurisdiction concerning lighting and dark sky protection as well as other applicable guidance and laws. There are currently no guidance or laws on exterior lighting within these counties, but should that change, Dead Horse Point State Park is committed to following them.

Lighting Standards

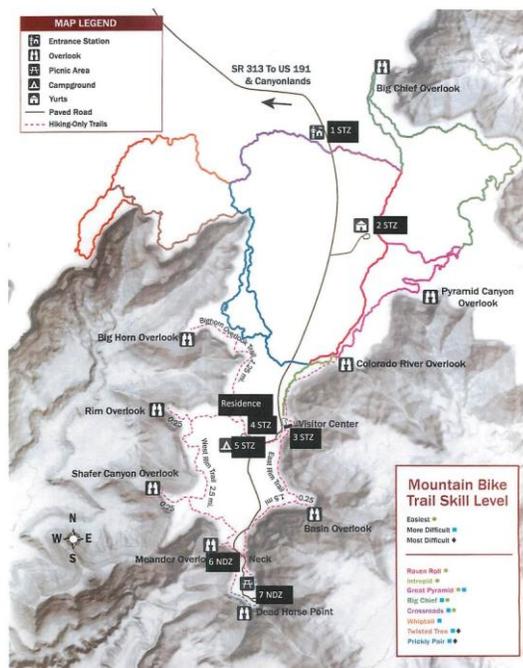
Standard Lighting Zone (SLZ)

Dead Horse Point State Park has altered and retrofitted much of the outdoor lighting in all the districts of the park. Permanent fixtures are allowed in this zone, provided they are limited to immediate task area. Artificial lighting is used only when necessary for safety, as in lights around fee stations, residential porches, campsites, yurts and visitor centers. Any future buildings or projects will conform to these standards. In order to alleviate light trespass, the following basic principles are observed:

- Light fixtures should exist only where needed for specific tasks.
- Light should only exist when necessary. Lights should operate on manual switches or motion sensors/timers.
- Light should only exist in the minimum amount necessary. Individual fixtures should be limited to 600 lumens, with exceptions for specific safety and special uses based on need.
- Lights should be selected with warm colors, such as amber ($\leq 2500\text{K}$ color temperature).
- Energy efficiency should be considered when choosing lighting. Standard bulbs should be or light-emitting diodes (LED).
- Lights should be directed downward and shielded.

Natural Darkness Zones (NDZ)

All areas not labeled with a number fall or marked with NDZ are under this zone. The Neck, Dead Horse Point, and backcountry areas are included in this zone. No permanent lighting exists or is allowed in this area. Light trespass from outside sources and SLZ is minimal and all attempts are made to eliminate any excess light pollution. This area makes up the large majority of Dead Horse Point State Park.



Lighting Adjustment Plan

Within five years of receiving an IDA designation, 100% of all exterior lighting will be in compliance with the Park's LMP and IDA International Dark Sky Park guidelines. Most fixtures and bulbs will be replaced before March 2016. Crystal White will continue to find fixtures and bulb solutions for all other lights before the end of the 5 year period.

Long Term Monitoring Commitment

Management and staff of Dead Horse Point State Park are committed to collecting long-term sky quality measurements and photo documentation. Our staff has purchased one basic Unihedron Sky Quality Meter and has created a data collection form to support long-term collection. Staff will collect data at each of the 7 collection sites at minimum six times per year and will collect additional measurements as weather and sky conditions allow. The park will also collect photo data once per year from two locations. This will provide tangible data to interpret future light infringement and monitor the lighting within the Park as well. Locations will be focused on public use areas where visitors would be most likely to enjoy the night sky, as well as areas of possible light trespass from outside of the park.

Night Sky Quality Surveys 2015-2016								
	Gate	Yurts	VC	Campground	Neck	Point	Residence	Ground Cover
12/15/2015	21.32	21.33	21.65	21.52	21.65	21.46	21.25	clear
1/11/2016	21.19	21.32	21.29	21.47	21.42	21.43	21.29	snow

The park is also allows for 24/7/365 unrestricted access within the day use areas for astrophotographers and night sky viewing.

Conclusion

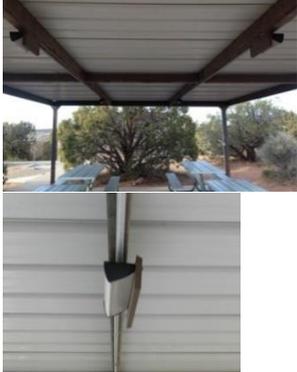
Dead Horse Point State Park is dedicated to maintaining a lighting system that is low-impact and exists only as necessary for safety. Future lights will comply with this low-impact lighting management system. Artificial lighting in the park does not exist in areas where there is an expectation for darkness by the visitor and employees.

Final Statement

After conducting night sky friendly interpretive programming for the last five years, it would be such a pleasure to receive this designation for Dead Horse Point State Park. The designation would help draw individuals to the park for the enjoyment of the amazing dark sky resource found within. Thank you all for your time in considering this application, your dedication to helping reduce light pollution and light trespass, and educating the world on how to protect natural darkness.



"Most days I live awed by the world we have still, rather than mourning the worlds we have lost. The bandit mask of a cedar waxwing on a bare branch a few feet away; the clear bright sun of a frozen winter noon; the rise of Orion in the eastern evening sky-every day, every night, I give thanks for another chance to notice. I see beauty everywhere; so much beauty I often speak it aloud. So much beauty I often laugh, and my day is made." --Paul Bogard

Dead Horse Point State Park's Exterior Lighting Inventory					
Location	Fixture	Full-shielded	Photo	Application	Conformity to LMP
Entrance Gate	1-Stop light	No		Safety	Yes
Entrance Gate	1-Caution light	No		Safety	Yes
Entrance Gate	1-Flag light	Yes with Rock		Flag illumination	Yes (17W LED fully shielded, looking for an affordable light from above)
Entrance Gate	1-Sign light	No		Informational	No (Researching options. Planned to be replaced July 2016)
Entrance Gate	4-Exterior lights	Partially shielded		Building egress	Yes
Entrance Gate	1-Envelope light	Fully shielded		Informational	Yes
Yurt Site	4-pavilion light	Partially shielded		Building egress	No (Wooden boxes will be built and placed around these lights before March 2016)

Residence 1	3-porch light	No shielding		Building egress	No (Fixtures ordered and 2 W amber LED bulbs to be replaced March 2016)
Residence 1	8-solar led	Fully shielded		Building egress	Yes
Residence 2	2-porch light	No shielding		Building egress	No (Fixtures ordered and 2 W amber LED bulbs to be replaced March 2016)
Residence 2	1-sodium light	No shielding		Grounds egress	Yes (Light does not function as wires are unplugged. Removal of pole in 2016)
Triplex	3-porch light	No shielding		Building egress	No (Fixtures and 2W LED bulbs to be installed by March 2016)
Shop	1-flood	No shielding		Building egress	Yes (17W LED bulb, only used in emergencies)
Fuel shed	1-flood	No shielding		Building egress	Yes (No bulbs, never used, removal of fixture 2016)
Fuel shed	1-solar light	Fully shielded		Building egress	Yes

Visitor center	10-emergency light	Fully shielded		Building egress	Yes (Emergency lights 17W LED bulbs, only used during emergencies)
Visitor center	5-exterior light	Fully shielded		Building egress	Yes (7w amber LED in place by March 2016)
Visitor center	1-sodium light	No shielding		Grounds egress	Yes (Light's wires have been unplugged. Removal of pole in 2016)
Visitor center	1-bulletin board light	Fully shielded		Informational	Yes (Wood piece blocks glare from all sides. Plastic cover has been painted dark red)
Visitor center	3-patio box light	No shielding		Building egress	Yes (No bulbs and never used, fixtures will be removed)
Campground	1-sodium light	No shielding		Grounds egress	Yes (Light's wires have been unplugged. No plan to fix light and pole will be used for internet)
Campground	23-site light	Fully shielded		Building egress	Yes (2w amber LED in place, fully shielded)
Campground	4-bathroom light	Fully shielded		Building egress	Yes (7w amber LED in place by March 2016)

Letters of Support



GARY R. HERBERT
Governor
SPENCER J. COX
Lieutenant Governor

State of Utah

DEPARTMENT OF NATURAL RESOURCES

MICHAEL R. STYLER
Executive Director

Division of State Parks and Recreation

FRED HAYES
Division Director

Board of Directors
International Dark-Sky Association
3223 North First Avenue
Tucson, AZ 85719

December 15, 2015

Dear IDA Board of Directors:

I am honored to support Dead Horse Point State Park's nomination for designation as an International Dark Sky Park (IDSP). Dead Horse Point was established as a Utah State Park in 1959 to preserve its scenic qualities and resources while providing quality recreational and educational opportunities for its visitors. The park receives over 330,000 visitors annually, with the majority of visitors coming from outside of Utah.

Crystal White, our assistant park manager reached 720 visitors in 2015 through interpretive programming highlighting the dark skies of Dead Horse Point and the area. She has partnered with recently designated Canyonlands National Park to provide free night sky programs for the public. It is through Crystal's passion and enthusiasm for the night sky that our staff was inspired to seek this designation for the park.

With IDSP designation, a dark sky friendly lighting plan, and continued dark sky education, we hope to inspire future generations of visitors to become stewards of the night sky in their communities.

Thank you for your consideration.

Sincerely,

Megan Blackwelder
Park Manager
Dead Horse Point State Park
meganblackwelder@utah.gov



Dead Horse Point State Park, PO Box 609, Moab, UT 84532-0609
telephone (435) 259-2614 • facsimile (435) 259-2615 • TTY (801) 538-7458 • www.stateparks.utah.gov

Bruce W. Browning
353 Sunshine Circle
Moab, Utah 84532

December 13, 2015

International Dark Sky Committee

I understand the committee is considering applications for "Dark Sky Park" designations from parks around the world and specifically from the Dead Horse Point State Park in Utah. As a local citizen and a member of the International Dark Sky Association I urge the committee to grant this designation to Dead Horse Point. Dead Horse Point is a well appreciated and well maintained little jewel of a park between Arches and Canyonlands National Parks. Its location therefore draws national and international visitors.

Last night just after sunset, at the invitation of Crystal White, ranger at the Dead Horse Point State Park, I drove to the park from my home in Moab, to check on how it looked in the dark. I was especially concerned since the BLM had allowed several oil wells to be drilled within night light view of the park. I was delighted to see, or rather not see, the oil well pumps and platforms completely hidden in darkness. Crystal explained their first night experiences with the oil installations were, as expected, brilliant productions of light. Fortunately Crystal found herself with the opportunity at a social event to speak quietly and pleasantly with an executive of the oil drilling company. She explained the virtues of a dark sky, including the benefits to wildlife, the aesthetics of a starry sky, the energy savings of intelligent lighting, all of which were available to Dead Horse Park because of its isolated location. The executive said nothing of his intentions but within weeks the disturbing lights on the oil pads had been shut off.

On my drive the entry gate to the park revealed itself by a very gently lighted American flag waving against a spectacular Milky Way. The park owns a 12 inch Dobson telescope which, with no moon and some expert explanations from Crystal gave good views of various nebulae. A few shots from the Gemini asteroid shower were also observed. My group went home elevated and inspired.

Respectfully Yours,


Bruce W. Browning

International Dark Sky Association Member

Dead Horse Point State Park



City of Moab
217 East Center Street
Moab, Utah 84532-2534
Main Number (435) 259-5121
Fax Number (435) 259-4135



Mayor: David L. Sakrison
Council: Kyle Bailey
Heila Ershadi
Doug McElhaney
Kirstin Peterson
Gregg W. Stucki

December 9, 2015

IDA Board of Directors
International Dark Sky Association
3225 North First Avenue
Tucson, Arizona 84719-2013

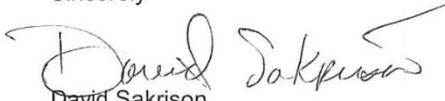
To Whom it May Concern:

As the Mayor of Moab I am writing to you on behalf of Dead Horse Point State Park in regards to their application designating them as a Dark Sky Park.

The City of Moab wholly endorses this designation. This is the premier park in the Utah State Park System. It borders Canyonlands National Park which recently received your designation.

We are obviously aware of the inherent value of such a designation which would lend itself to many visitors coming to Moab and the surrounding parks. We as a City encourage you to designate Dead Horse Point State Park as a Dark Sky Park.

Sincerely


David Sakrison
Mayor
City of Moab



Colorado Plateau Dark Sky Cooperative

2282 S. West Resource Blvd

Moab, UT 84532

January 15, 2016

VIA ELECTRONIC COPY ONLY- NO HARD COPY TO FOLLOW

Crystal White – Assistant Park Manager
 Dead Horse Point State Park
 PO Box 609
 Moab, UT 84532

Dear Ms. White:

The Colorado Plateau Dark Sky Cooperative is pleased to support the Dead Horse Point State Park International Dark Sky Park nomination. Dead Horse Point State Park is located in one of the darkest regions in the continental U.S., and offers an exceptional, unfettered view of the dark night skies over the Colorado Plateau. The dark skies of Dead Horse Point State Park have immense value to astronomical viewing, local tourism, and wildlife conservation in the region. For the last five years, Dead Horse Point has hosted a series of astronomy events that are free to the public. In addition, Dead Horse Point State Park International Dark Sky Park designation would assist in the conservation of dark night skies in neighboring Canyonlands National Park, a recently awarded International Dark Sky Park. Dead Horse Point and Canyonlands have hosted events together for the last 2 years, and already have a full schedule of astronomy events planned for 2016. Dead Horse Point State Park has shown exceptional commitment to conserving natural darkness, and we anticipate their success will set an outstanding example for other parks to follow.

As an essential piece of the Colorado Plateau Dark Sky Cooperative, Dead Horse Point State Park is taking lighting, conservation, and educational steps to help fulfill the mission of the NPS Call To Action #27, Starry Starry Night. This voluntary initiative forms America's first Dark Sky Cooperative, and links communities, tribes, businesses, state/federal agencies, and citizens in a collaborative effort to celebrate the view of the cosmos, minimize the impact of outdoor lighting, and ultimately restore natural darkness to the area. Dead Horse Point State Park International Dark Sky Park designation would bring further awareness and legitimacy to the Cooperative and its actions.

We fully support the efforts of Dead Horse Point State Park as they seek designation of the Dead Horse Point State Park International Dark Sky Park. Such efforts to conserve dark skies will benefit residents, visitors, local economies, nearby communities, and future generations. Should you have any questions, please contact Nate Ament at 435-719-2349.

Sincerely,

Nate Ament

International Dark Sky Association member



United States Department of the Interior

NATIONAL PARK SERVICE
 Southeast Utah Group
 Arches and Canyonlands National Parks
 Hovenweep and Natural Bridges National Monuments
 2282 S. West Resource Boulevard
 Moab, Utah 84532-3298



IN REPLY REFER TO:

L7019

January 27, 2016

The Southeast Utah Group of national parks fully supports the Dead Horse Point State Park nomination for International Dark Sky status.

Southeastern Utah, where both the Southeast Utah and Dead Horse Point State Park are located, is one of the darkest regions in the country. Visitors to this area can experience a quality of natural darkness that is no longer possible for many who live in urban areas. For the past five years, Dead Horse Point State Park has shown a commitment to the preservation of this unique experience for its visitors. Most notably, the park successfully dialoged with the local extraction industry to reduce unneeded lighting, improving the skies over Dead Horse as well as those near Canyonlands National Park. The park's commitment to both education and resource preservation exemplifies the NPS Call to Action #27, Starry Starry Night.

During the visitor season, staff at Dead Horse Point State Park partner with rangers at Canyonlands and Arches National Parks to present free astronomy programs to visitors at all three parks. These popular events offer education about dark-skies preservation as well as high-quality interpretive program experiences. A schedule of these monthly cooperative events is already planned for 2016.

Three of the four parks in the Southeast Utah Group have already obtained International Dark Sky status. Natural Bridges National Monument became the world's first International Dark Sky Park in 2007. Hovenweep National Monument received its designation in July 2014, and Canyonlands followed in September 2015. Arches National Park is in the process of assembling an application packet. It would be very fitting for Dead Horse Point State Park to obtain recognition for the exceptionally dark skies shared across all these special places.

We support the recognition of Dead Horse Point State Park as an International Dark Sky Park for the enjoyment and benefit of residents, visitors, and future generations.

Sincerely,

Kate Cannon
 Superintendent
 Southeast Utah Group