Flagstaff Area National Monuments International Dark Sky Park Designation Nomination Package

January 2016

Table of Contents

Cover photo: Milky Way Wukoki Pueblo
Photo/Stan Honda

Flagstaff Area National Monuments International Dark Sky Park Summary

The Flagstaff Area National Monuments include Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments. Each of these monuments offers a spectacular resource that reflects the criteria desired for designation as a dark sky park. Due to the high elevation, dry air and clear skies, and status as a unit of the National Park Service, the Flagstaff Area National Monuments (FLAG) have the ability to preserve, protect, and serve as a role model in the conservation of night skies, especially for furthering those efforts close to largely populated areas.

The monuments are closed at night except for supervised access during the Crack-in-Rock guided overnight hikes and interpretive programs. The park roads are open 24 hours a day, seven days a week.

Our publicly visible restoration project is the interpretation of our night sky lighting retrofits, see pages 30 and 35 for more information.

All of the criteria addressed under the silver-tier status requirements are met at the Flagstaff Area National Monuments. Four of the seven indicators are met at the gold-tier status. Based on FLAG's qualifications in each of the following categories designated by the IDA, we feel that the monuments should be considered for the Silver 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 lightscapes.**

2) **Artificial Light and Skyglow: Typical observer is not distracted by glary light sources. Light domes present around horizon but do not stretch to zenith.**

3) **Observable Sky Phenomena: The full array of visible sky phenomena can be viewed. The Milky Way is seen on every clear night throughout the year, as well as faint meteors and the zodiacal light.**

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.**

5) **Visual Limiting Magnitude: Equal or greater than 6.8 under clear skies and good seeing conditions.** In 2012, the NPS Night Skies Team measured Zenith Limiting Magnitudes of 6.8, 6.8, and 6.10 at the monuments.

6) **Bortle Sky Class: 3-5.** The NPS Night Skies Team has determined Bortles classes of 2 at Wupatki, 3 at Sunset Crater Volcano, and 4 at Walnut Canyon, based on measurements from multiple nights.

7) **Sky Quality Meter: > 21.54.** This measurement is based on data collected by the NPS Night Skies Team using Unihedron meters as well as a data matrix to produce a "synthetic" SQM.

Nomination Letter

To Celebrate, Promote and Protect
the Glorious Dark Skies of Flagstaff and
Northern Arizona

P.O. Box 1892, Flagstaff AZ 86001

December 7, 2015

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

Dear IDA Board of Directors,

It is with great pride that the Flagstaff Dark Skies Coalition, a recognized Chapter of IDA and the originators of the International Dark Sky Places program, nominates The Flagstaff Area National Monuments to become an International Dark Sky Park.

As the First International Dark-Sky Community, Flagstaff has been a leader in preserving and protecting the night sky in Flagstaff and Northern Arizona. We are pleased that The Flagstaff Area National Monuments is joining the effort to protect night skies by seeking the designation as an International Dark-Sky Park. Recognizing The Flagstaff Area National Monuments as a Dark-Sky Park would continue to expand and cement the culture of night sky protection in the region as already demonstrated by Flagstaff, Sedona, and the recent application for International Dark-Sky Community status of the Village of Oak Creek.

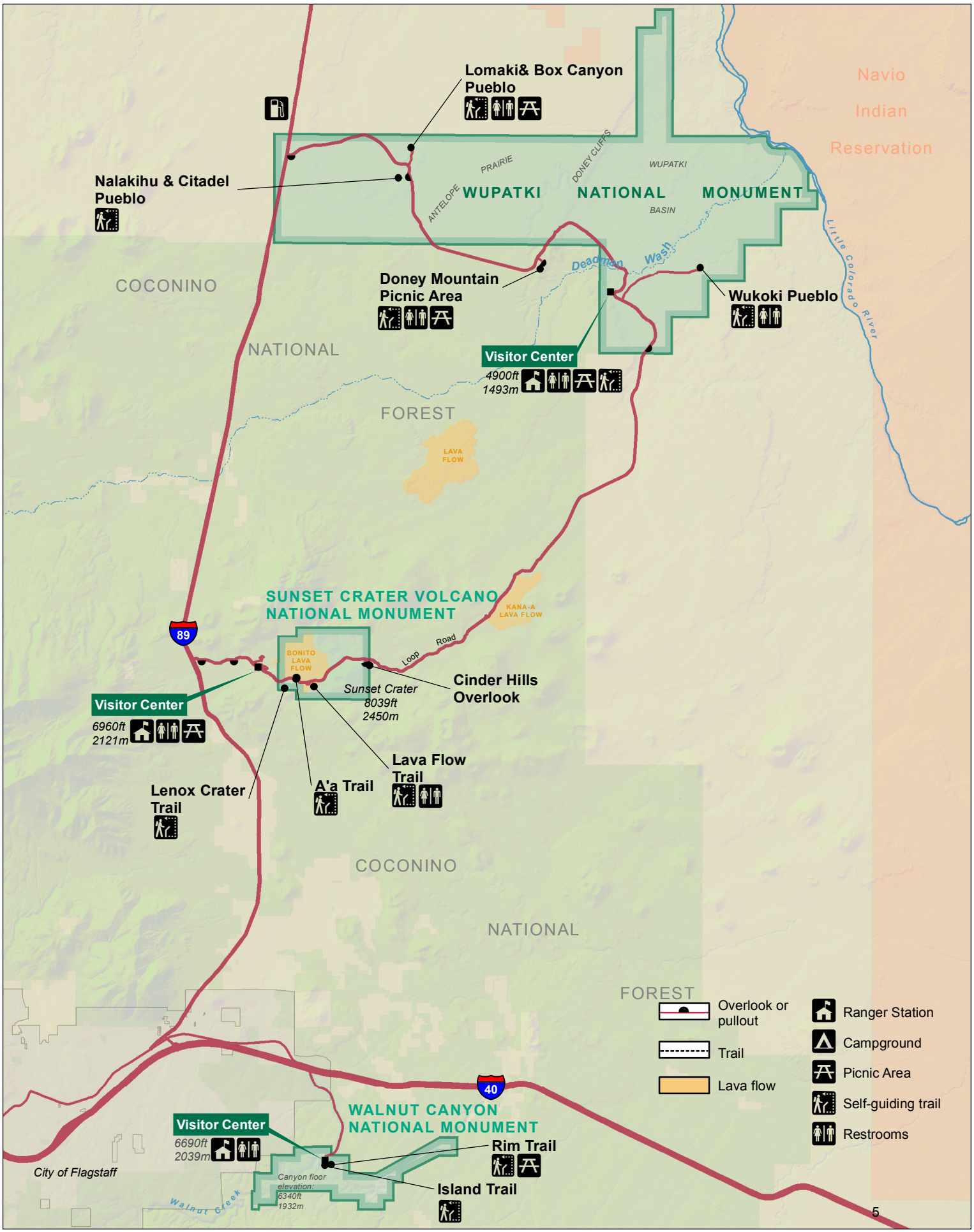
The Flagstaff Area National Monuments, composed of Walnut Canyon National Monument, Wupatki National Monument, and Sunset Crater Volcano National Monument are managed jointly. They have created a plan to reduce and control artificial light at night and to continue to promote and expand their community education and outreach programs at each Monument.

In conjunction with the 100th anniversary of the National Park Service it would be a fitting to have the Flagstaff Area National Monuments designated as an International Dark-Sky Park in 2016.

Sincerely,

Debra Briggs Luginbuhl
Flagstaff Dark Skies Coalition

Map of the Flagstaff Area National Monuments



1 Description of Night Sky Resources

Sunset Crater Volcano
Photo/Chris Luginbuhl

Location and Description of the Parks

Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monument were established by presidential proclamation in 1915, 1930, and 1924 respectively for a total area of 41,991 acres. These three monuments are managed by the National Park Service as the Flagstaff Area National Monuments. Within these monuments, one private inholding exists in Walnut Canyon. This tract is 237 acres and has been unused since the monument was established. The landowner has expressed willingness to consider National Park Service acquisition through exchange, or purchase. The NPS is currently working towards this goal.

Walnut Canyon National Monument

Walnut Canyon National Monument protects a dense concentration of exceptionally well-preserved prehistoric cliff dwellings just 10 miles from downtown Flagstaff, Arizona. The monument contains more than 500 archeological sites along 10 miles of Walnut Creek. The deep pools and reliable flow of the creek made the canyon a rare and valuable home for the Northern Sinagua people and supports the rich biological communities of this dry landscape. Scattered families farmed the upland areas around Walnut Canyon for hundreds of years, growing small gardens of corn, squash, and beans. After the eruption of Sunset Crater Volcano in the 11th century, the population of the area grew significantly and people began constructing dwellings in the limestone alcoves below the canyon rim.

Stark variations in elevation and exposure in the canyon have created a unique biological hot spot where distinct ecological communities overlap and interact. Its location and orientation make it an important wildlife corridor, and even though the monument is relatively small, it provides habitat for numerous charismatic or rare wildlife species, such as mule deer, elk, black bear, mountain lion, peregrine falcon, and Mexican spotted owl. Dark night skies and low ambient sound levels contribute to the natural setting and biological diversity of Walnut Canyon. The monument contains a national register-listed cultural landscape, the Headquarters Area Historic District.

Walnut Canyon's ancient dwellings and rich assortment of plants and animals hold traditional cultural importance for numerous tribes in the Southwest. For the American Indian people whose ancestors occupied the canyon for approximately 150 years, these sites contain evidence and information that verifies oral histories and maintains cultural identities. Volcanic eruptions and other geologic processes, combined with ancient and modern human influences in the area, highlight the dynamic nature and interplay of social and environmental history. Aside from its value as a classroom for science and research, the monument represents an outstanding scenic and recreational attraction for visitors and local residents.

Sunset Crater Volcano National Monument

Sunset Crater Volcano National Monument is approximately 20 miles northeast of downtown Flagstaff in northern Arizona. The park is situated east of the tallest peak in Arizona among hundreds of volcanic features. The monument protects 3,040 acres representing the Colorado Plateau's most recent volcanic eruption. It is the youngest, least-eroded cinder cone in the San Francisco Volcanic

Field and represents the only series of eruptions in the Southwest indisputably witnessed by local peoples. Much of the ground surface is covered by lava flows or deep volcanic cinder deposits, and at first glance, the landscape still appears stark and inhospitable. Nestled within the dramatic geologic features are small islands of pine and aspen trees, desert shrubs, and wildflowers that provide small but unique habitats for wildlife. Over several hundreds of years, life is slowly beginning to return to the landscape.

The significance of Sunset Crater Volcano National Monument extends beyond the geological events themselves. The powerful geologic processes that formed the volcano profoundly affected the way of life of local inhabitants during the 11th and 12th centuries and forever changed both the landscape and the ecology of the area. This volcano and its relatively undeveloped landscape provide an unparalleled opportunity to study succession and ecological change in an arid volcanic landscape.

Wupatki National Monument

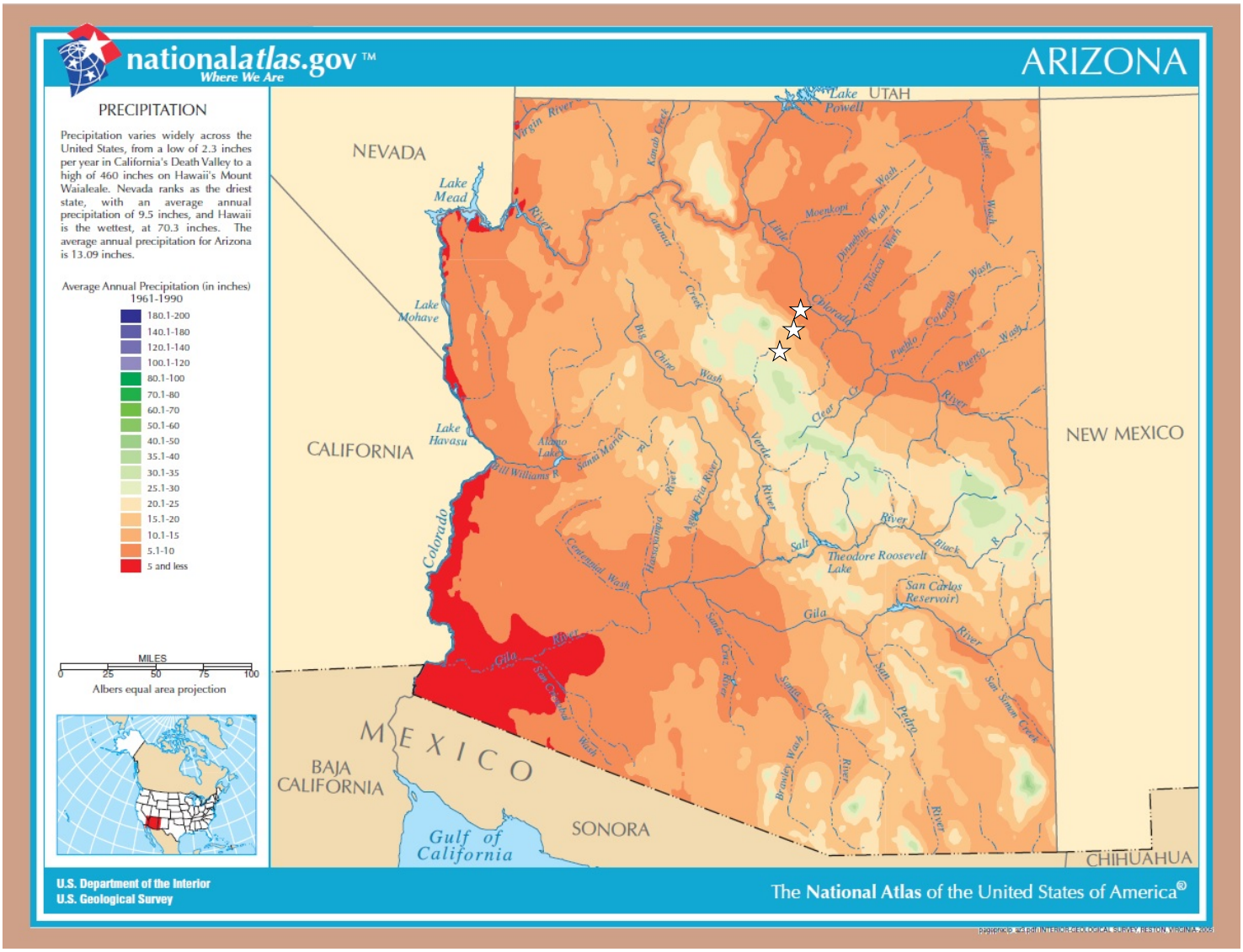
Wupatki National Monument preserves numerous archeological sites of ancient peoples on the southwestern Colorado Plateau. The monument occupies 56 square miles of dry, rugged land 26 miles north of Flagstaff, Arizona, and is characterized by dramatic geologic landforms, climatic extremes, scarce water, and diverse plant and animal species.

Wupatki and the surrounding area contain more than 5,000 archeological sites, dating mostly to the period after the eruption of nearby Sunset Crater Volcano in the 11th century. These sites range from single-room field houses to exceptionally well-preserved, free-standing pueblos of 50 to 100 rooms. A cultural crossroads, Wupatki was home, at various times, to several American Indian tribes and preserves a tangible record of clan migrations and the extensive trading practices through the centuries. The monument contains a national register-eligible cultural landscape, the Visitor Center Complex Historic District.

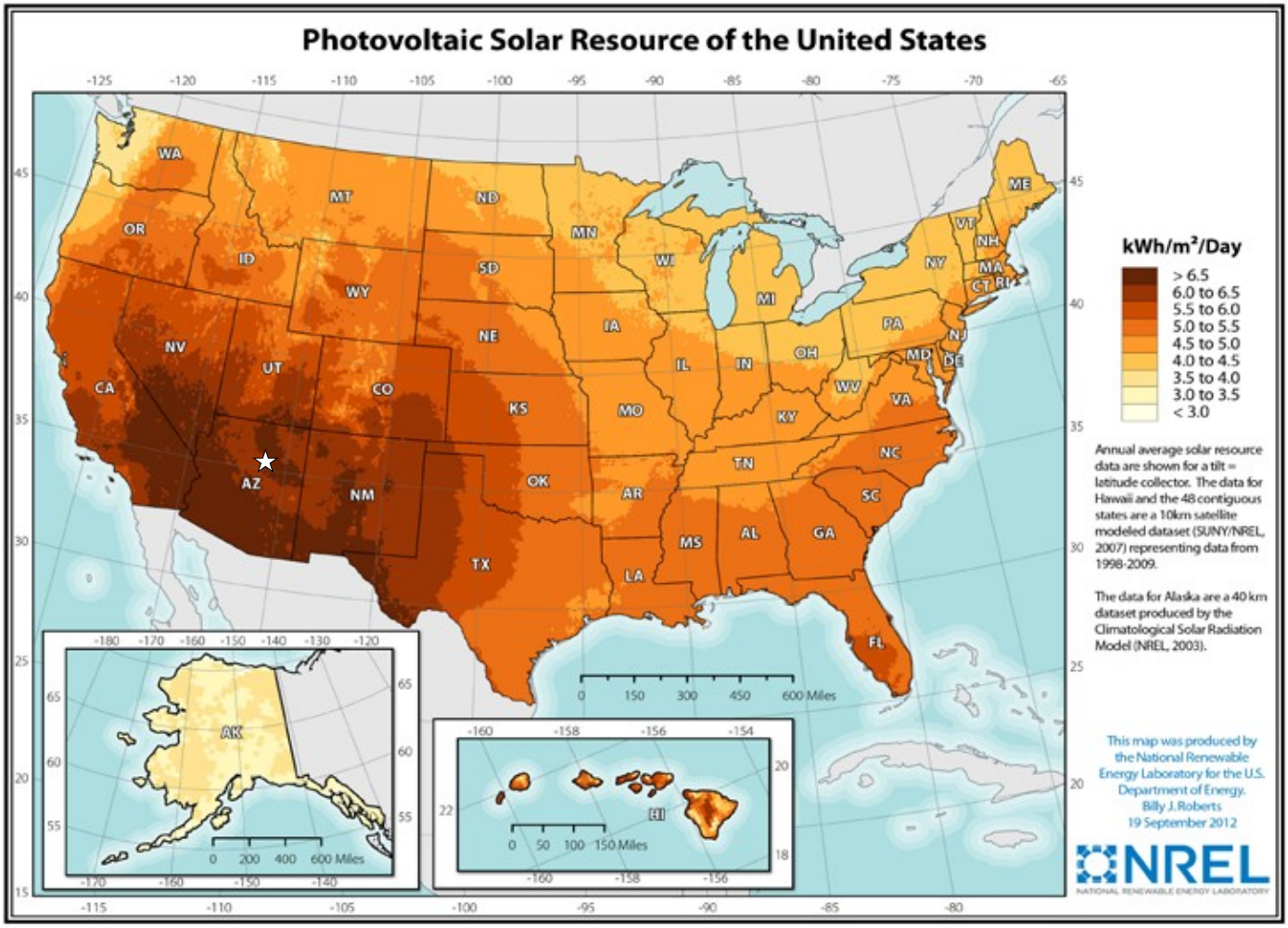
Undeveloped, with few impacts from nearby communities, the monument provides an increasingly rare opportunity to view a vast dark night sky and experience natural sounds much like Wupatki's early inhabitants. Broad vistas of desert grasslands, mesas, buttes, the Painted Desert, and volcanic hills contrast sharply with the San Francisco Peaks, which are visible in the distance across the Wupatki landscape.

Weather, Climate, and Visibility

The Flagstaff Area National Monuments have an arid climate with precipitation ranging from 18 inches at Walnut Canyon to eight inches at Wupatki annually. Park elevation varies between just under 4,400 feet at the level of the Little Colorado River to just over 8,000 feet at the peak of Sunset Crater Volcano.



Average annual precipitation map of Arizona. Stars mark each monument's approximate location. (www.nationalatlas.gov)



Map showing insolation received as a proxy for cloud-cover. Star marks monuments' approximate location. Source: www.nrel.gov

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 astrophotographs. Only the observation of planets and double stars is unaffected. Low light pollution conditions, or dark skies, are one of the most important properties of a good astronomical observing site.

The Flagstaff Area National Monuments vary in isolation from cities and towns. The monuments and their immediate environs produce little light pollution of their own, with minimal measurable amounts from Walnut Canyon and Sunset Crater Volcano and almost no light pollution at Wupatki. The monuments are in proximity to Flagstaff, Arizona, a city with a population of over 65,000 people. Fortunately, Flagstaff is the first International Dark Sky City and has strict lighting codes. In 2015-2016, a group of local stakeholders, including the Flagstaff Area National Monuments, are working to review and update the city's original lighting codes with an ultimate goal of presenting the city council with suggested revisions to the code. Another large neighbor of the monuments, Coconino County, is working on revising their lighting codes concurrently and potentially extending special protection zones around each of the monuments to preserve this recognized locally significant resource. The nearby communities of Sedona (also an International Dark Sky City) and Cottonwood also have strict lighting codes that help protect the region surrounding the Flagstaff Area National Monuments.

Flagstaff Code: http://www.flagstaff.az.gov/index.aspx?NID=2998

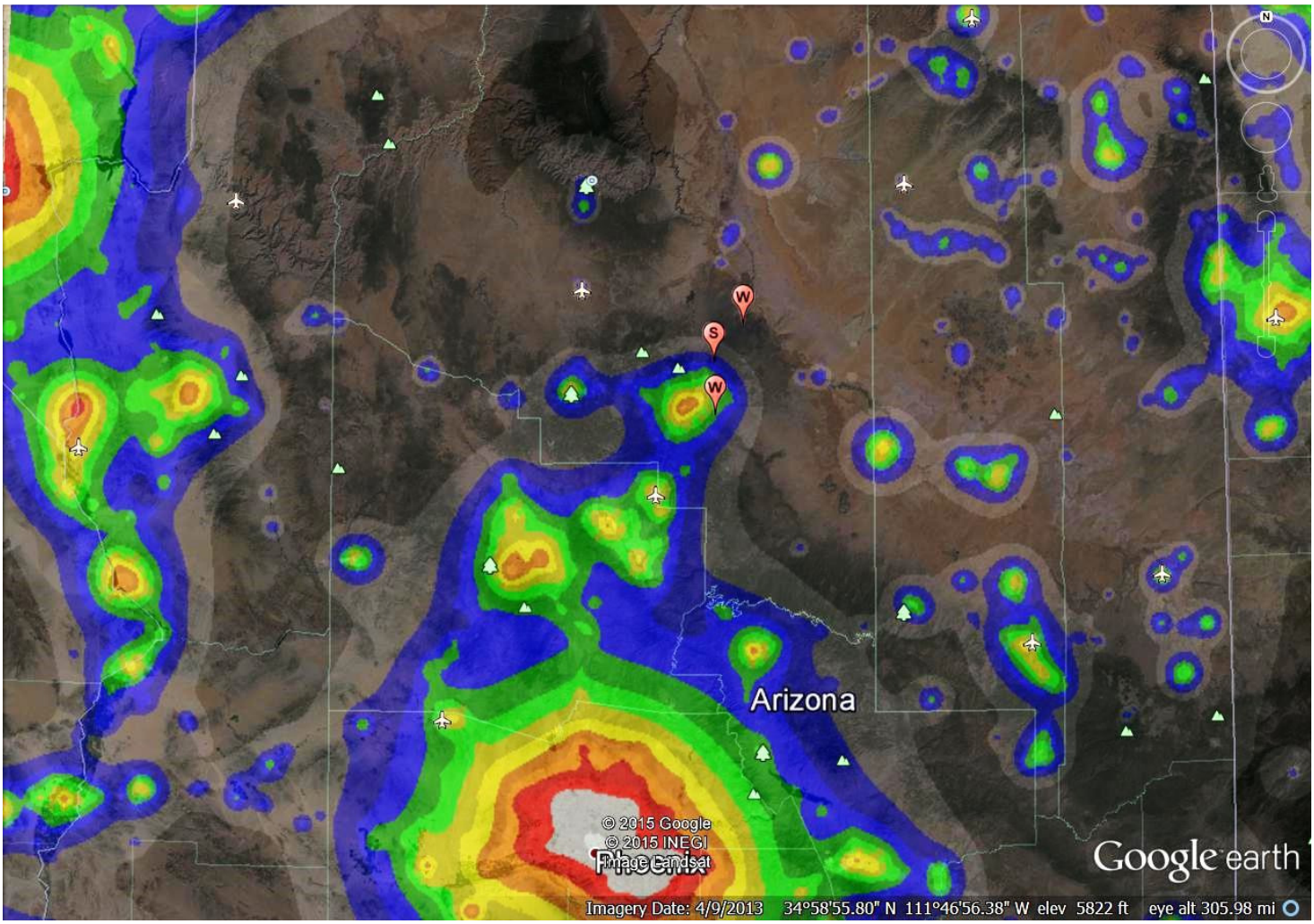
Coconino County Code: http://coconino.az.gov/DocumentCenter/View/3004

Sedona Code: http://www.codepublishing.com/AZ/sedona/html/SedonaLDC/SedonaLDC09.html#911

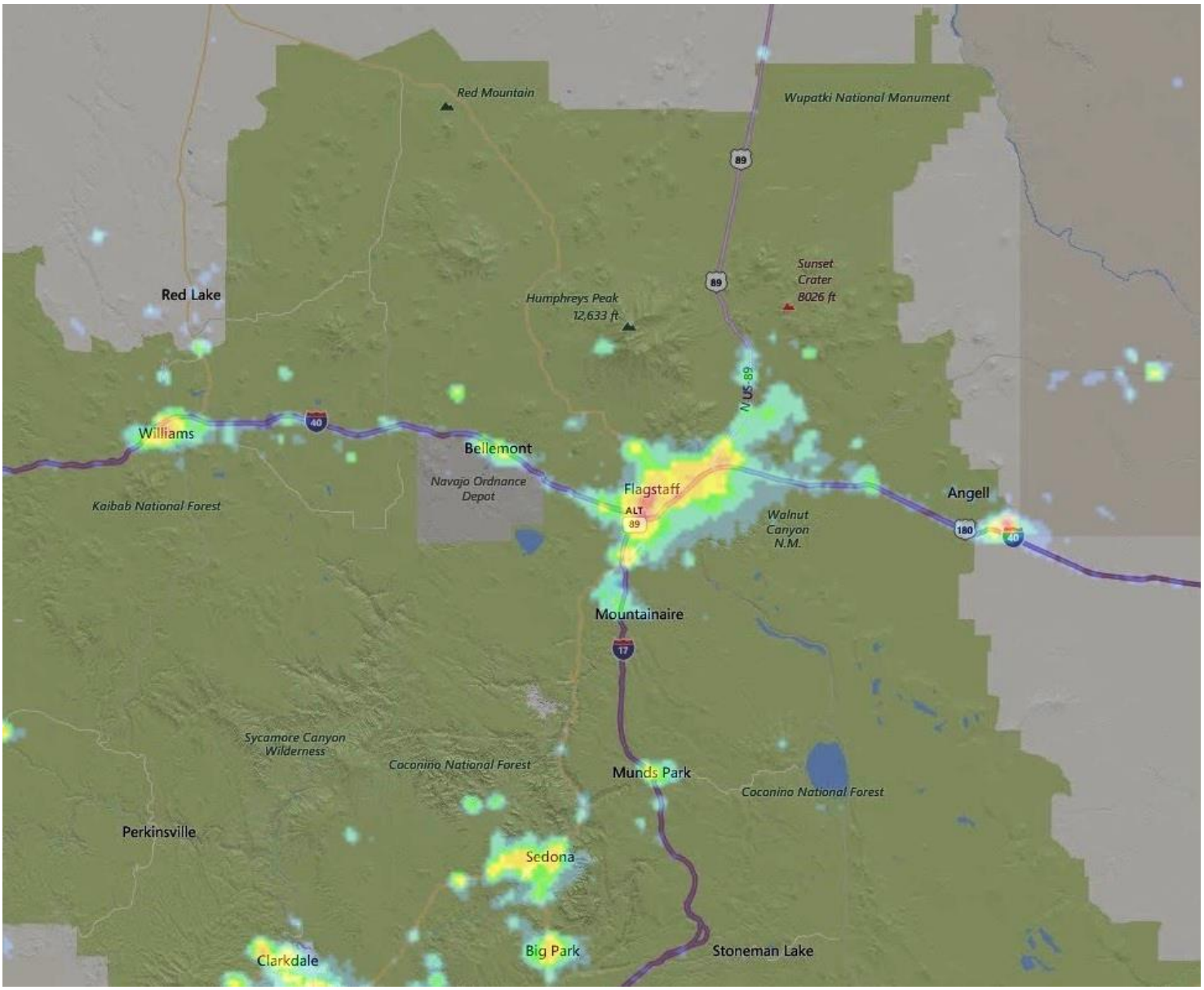
Cottonwood Code:
http://cottonwoodaz.gov/planning/ZoningOrd/Outdoor%20Lighting%20Requirements.pdf

This map is an excerpt from the Light Pollution Atlas 2006 by David Lorenz. Lorenz recalculated The World Atlas of the Artificial Night Sky Brightness with newer data.

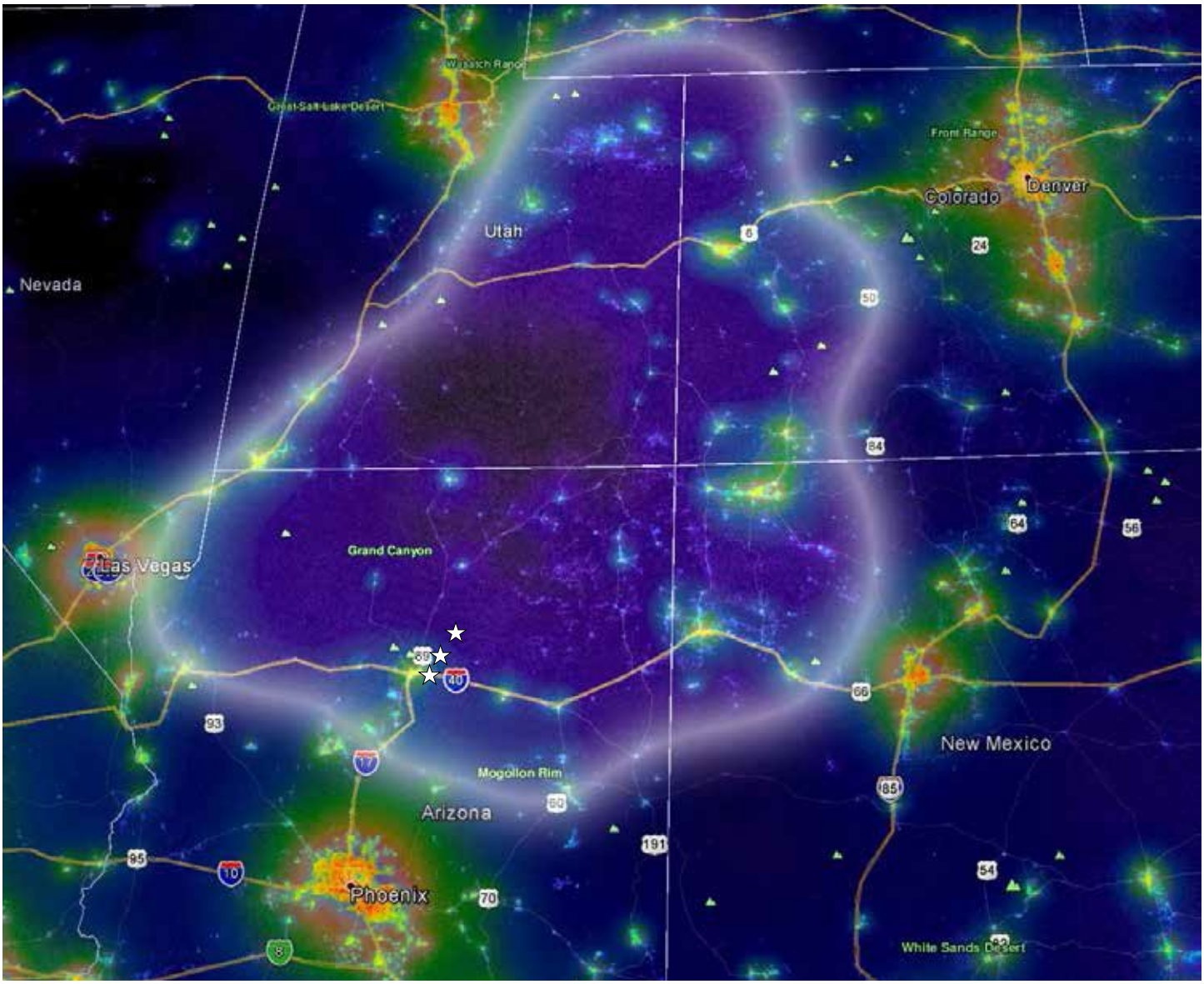
The map is overlaid on Google Earth with each of the three monuments pinpointed. This map assumes an observer at sea level. An observer at the three monuments shouldsee a slightly darker sky. The outskirts of Las Vegas, Nevada appear on the northwest corner of this map and most of the Phoenix area appears to the south.



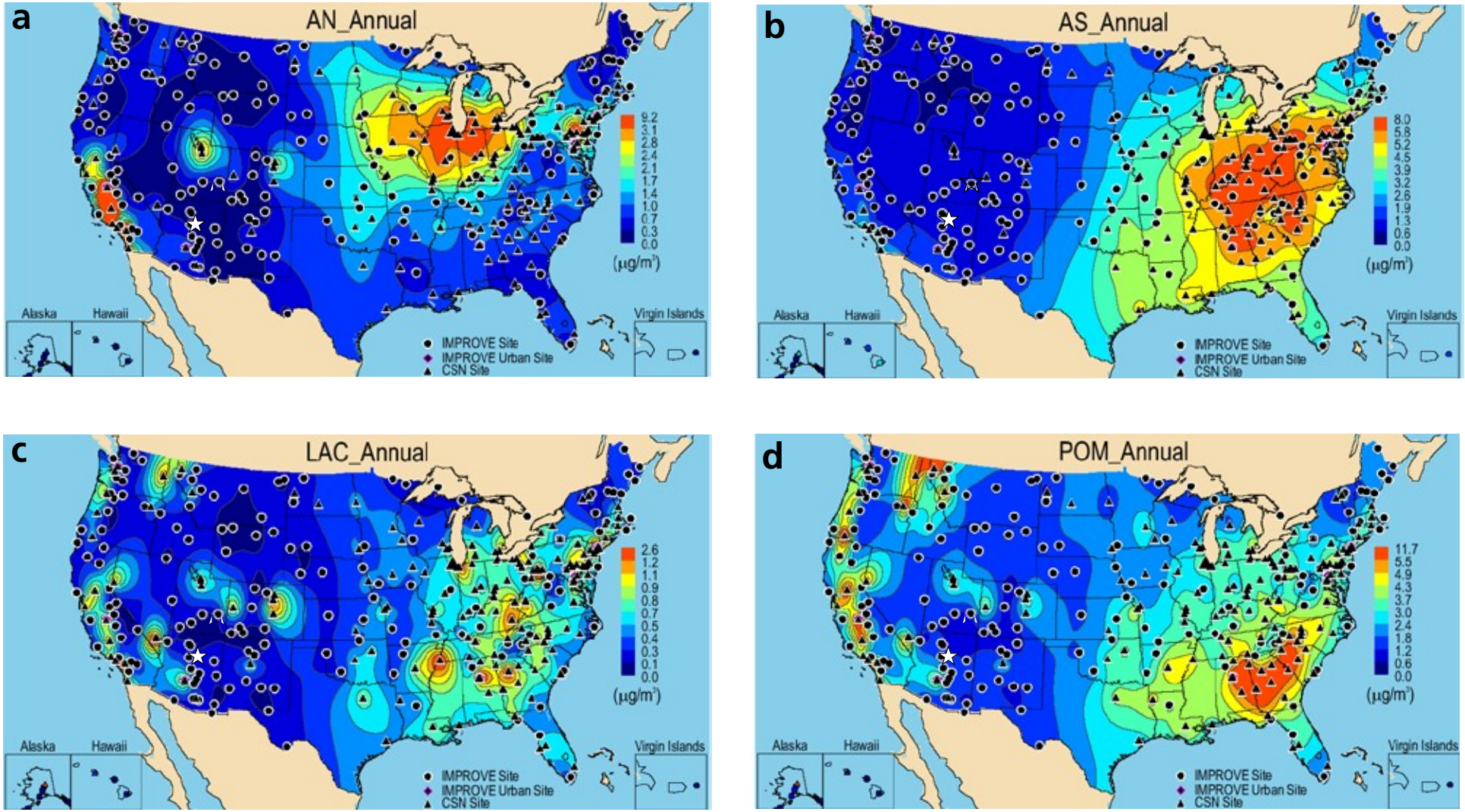
Source: ClearDarkSky.com



Light Pollution Map (2014)
Source: www.lightpollutionmap.info



Outline of Colorado Plateau with light pollution sources. Stars mark approximate location. NPS Night Skies Team Anthropogenic Light Ratio Continental Model (2014)



Contour maps of various constituents of air pollution that impact visual clarity of the atmosphere. (a) Ammonium Nitrate, (b) Ammonium Sulphate, (c) Light absorbing carbon, (d) Particulate Organic Matter. Data provided by the Interagency Monitoring of Protected Visual Environments (IMPROVE) network. Annual mean mass concentrations for measurements taken between 2005-2008 (µg m^{-3}). Adapted from Hand, et. al 2011. Stars mark monuments' approximate location.

Assessment of Sky Quality at Flagstaff Area National Monuments

Sky quality data were collected at the Flagstaff Area National Monuments by the National Park Service Night Skies Team. They provided the following explanations and data

Introduction and Methods
The U.S. National Park Service Night Skies Program routinely collects calibrated high resolution night sky brightness measurements over the entire hemisphere of the sky using a wide-field CCD camera and optics approximating the Johnson-Cousins V photometric band (Duriscoe, Luginbuhl, and Moore, 2007). In addition, a model of the natural sky brightness for a given location, date, and time of observation, estimated airglow brightness at the zenith, and atmospheric extinction coefficient is constructed in order to estimate the anthropogenic component of sky brightness (Duriscoe, 2013). A single data set is comprised of 45 square format images obtained over a period of about 20 minutes using a portable robotic telescope mount. The images are mosaicked into an all-sky map of sky brightness. Calibration in the V photometric band is accomplished by automated all-sky aperture photometry of selected standard stars observed on every data set. In this manner both the instrument zero-point and the atmospheric extinction coefficient are determined. The original resolution of the mosaics is about 34 million pixels/hemisphere. These are resampled to 0.05 degrees per pixel (8.25 million pixels/hemisphere) after the stellar photometry is performed and the sky background brightness is extracted by median filtering for analysis. A mosaic of the modeled natural sky brightness is produced matching the time of observation of each individual data frame. After subtraction of the model from the data mosaic, the result yields an estimate of the anthropogenic light (the sky glow mosaic).

This equipment and data reduction technique were utilized at the Flagstaff Area National Monuments on March 13 & 15, 2012. The results are presented herein in the form of false-color all-sky maps of sky brightness and tables of sky brightness summary statistics derived from the mosaics. The anthropogenic sources are identified and discussed. Dates and times are given in Local Mean Time (LMT).

The instruments are calibrated in V-magnitudes, but may be converted to units of luminance using the relation published by Garstang (1986, Eq. 19). This yields linear units of nano-Lamberts. The luminous emittance of each pixel in milli-lux may be computed given its luminance and solid angle. If the mosaics are analyzed in an equal-area projection, the relative contribution of each area of the sky will be the same. This is important in computing illuminance from the entire sky. We propose the following all-sky statistics as a means of quantifying visual sky quality: 1) zenith luminance, 2) average luminance, 3)horizontal illuminance, 4)maximum vertical illuminance. These statistics are derived for both the sky brightness data mosaic (including natural sources) and the sky glow mosaic (including only anthropogenic sources).

Each of the four indicators described above may also be expressed at a ratio to natural reference conditions. We propose the following values as the median reference condition over the sunspot cycle: 1) zenith luminance 172 ucd/m2, 2) average all-sky luminance 248 ucd/m2, 3) horizontal illuminance 0.80 mLux, and 4) vertical illuminance 0.40 mLux. Data presented as a light pollution ratio (LPR) are the ratio of the sky glow mosaic value to these values.

NPS NIGHT SKIES PROGRAM DATA NIGHT REPORT

WACA120314 Walnut Canyon NM **Rim Overlook** **14-Mar-12**

Data Night Attributes

Longitude:	-111.50551	Camera:	IMG 1	Air temp. (C):	10.0	ZLM:	6.80	OBS_1:	J White
Latitude:	35.16987	# of sets:	8	R. H. (%):	10.7	BORTLE:	4	OBS_2:	C Leumas
Elevation (m):	2032	Exposure (secs):	12	Wind Speed (mph):	1	SQM:		OBS_3:	

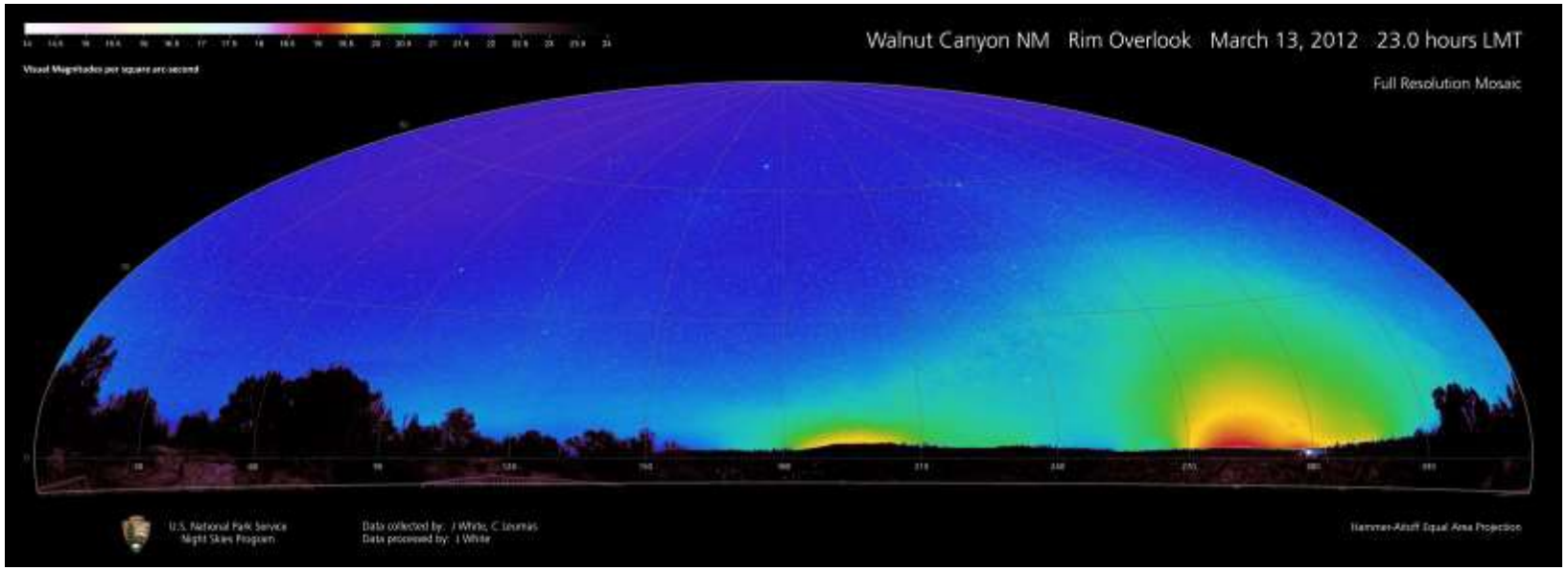
NARRATIVE: Flagstaff light dome dominated the southwest horizon, but the impact of the light dome diminished sharply when looking in other directions. High cirrus clouds lingering overhead, but slowly clearing. Clouds still present for first two sets before clearing off. WACA and SUCR setup on same night, remaining atmosphere condition notes taken at SUCR and are as follows: Clouds have cleared to 0% with very good transparency. Airglow bright but smooth.

Data Set Attributes

	Quality Flags				Natural Sky Model			Extinction				Collection Properties			
Data Set	Use-able	Col-lection	Pro-cessing	Atmo-sphere:	Zenith airglow (µcd/m²)	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	3	4	3	134	2	clouds overhead, poor subtraction	0.270	0.16	56	20	2	0.50	0.91	13.0
2	Y	3	4	3	181	2	clouds overhead, poor subtraction	0.337	0.17	73	23	2	0.51	0.90	15.3
3	Y	3	4	5	134	4	improved conditions, good subtraction	0.195	0.04	87	0	1	0.50	0.90	15.5
4	Y	3	4	5	121	5	excellent subtraction	0.198	0.04	90	3	0	0.50	0.90	13.4
5	Y	3	4	5	115	5	excellent subtraction	0.192	0.04	93	1	0	0.50	0.90	13.2
6	Y	3	4	5	108	5	excellent subtraction	0.189	0.03	87	1	0	0.50	0.90	12.4
7	Y	3	4	5	108	5	excellent subtraction	0.188	0.03	90	0	0	0.51	0.89	12.2
8	Y	3	4	5	127	3	issues with images and stitchiong between rows	0.187	0.03	94	0	0	0.51	0.90	8.5

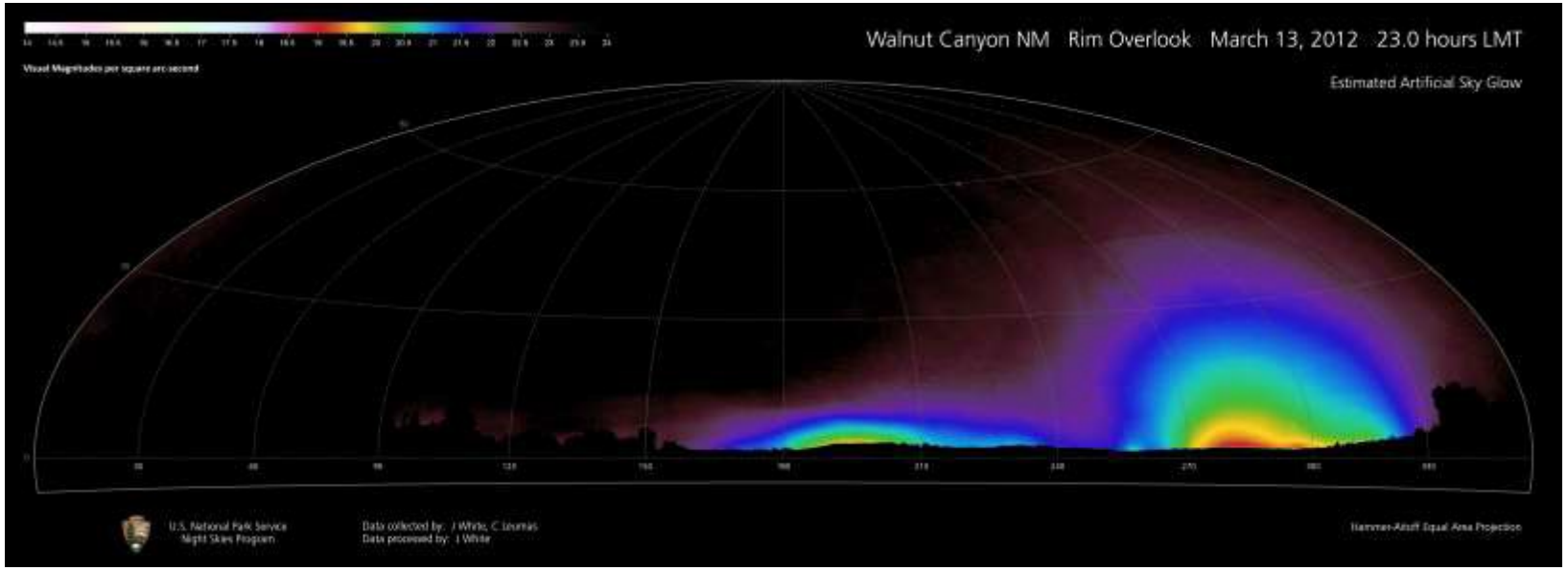
Populated Places

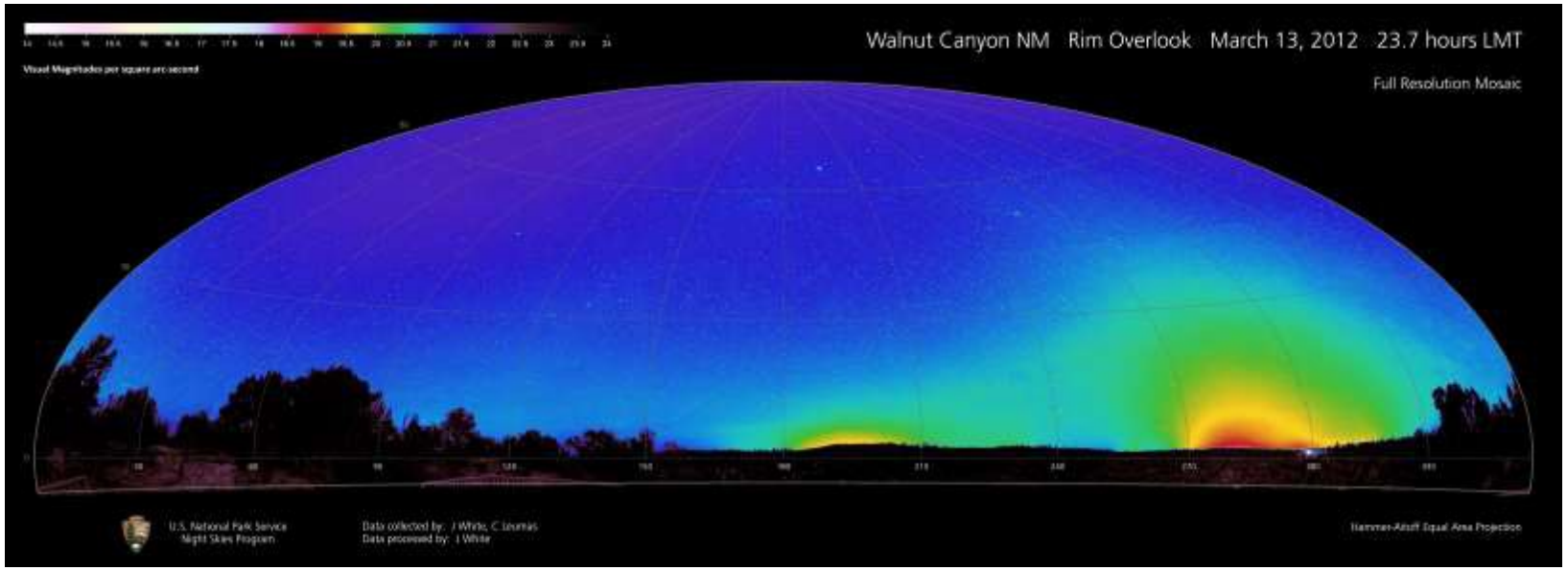
Place	Population (2010)	Distance (km)	Azimuth	Walker's	Apparent Half-Width (degrees)
Flagstaff city	65,870	10.6	279	17.993	34.4
Doney Park CDP	5,395	11.0	0	1.351	17.7
Phoenix city	1,445,632	185.4	197	0.309	6.4
Kachina Village CDP	2,622	19.1	243	0.164	3.0
Mountainaire CDP	1,119	15.3	236	0.123	10.8
Mesa city	439,041	197.4	186	0.080	3.1
Sedona city	10,031	43.6	217	0.080	5.2
Scottsdale city	217,385	169.3	190	0.058	4.2
Glendale city	226,721	192.4	199	0.044	2.1
Prescott Valley town	38,822	97.4	230	0.041	3.3
Peoria city	154,065	170.4	206	0.041	4.0
Village of Oak Creek (Big Pa	6,147	49.0	208	0.037	2.4
Chandler city	236,123	212.1	189	0.036	2.0
Fort Valley CDP	779	22.1	296	0.034	6.5
Gilbert town	208,453	207.8	186	0.033	2.1
Prescott city	39,843	108.1	233	0.033	3.1
Verde Village CDP	11,605	67.6	221	0.031	2.0
Cottonwood city	11,265	67.4	222	0.030	3.1
Tempe city	161,719	201.8	191	0.028	1.6
Tucson city	520,116	340.2	170	0.024	2.3
Surprise city	117,517	187.9	208	0.024	2.8
Las Vegas city	583,756	358.9	290	0.024	1.7
Camp Verde town	10,873	74.0	206	0.023	4.6
Winslow city	9,655	74.2	102	0.020	2.5
Lake Montezuma CDP	4,706	65.1	205	0.014	2.8
Payson town	15,301	104.3	171	0.014	2.2
Munds Park CDP	631	29.5	199	0.013	8.3
Albuquerque city	545,852	441.5	90	0.013	1.6



PHOTOMETRY OF ALL SOURCES

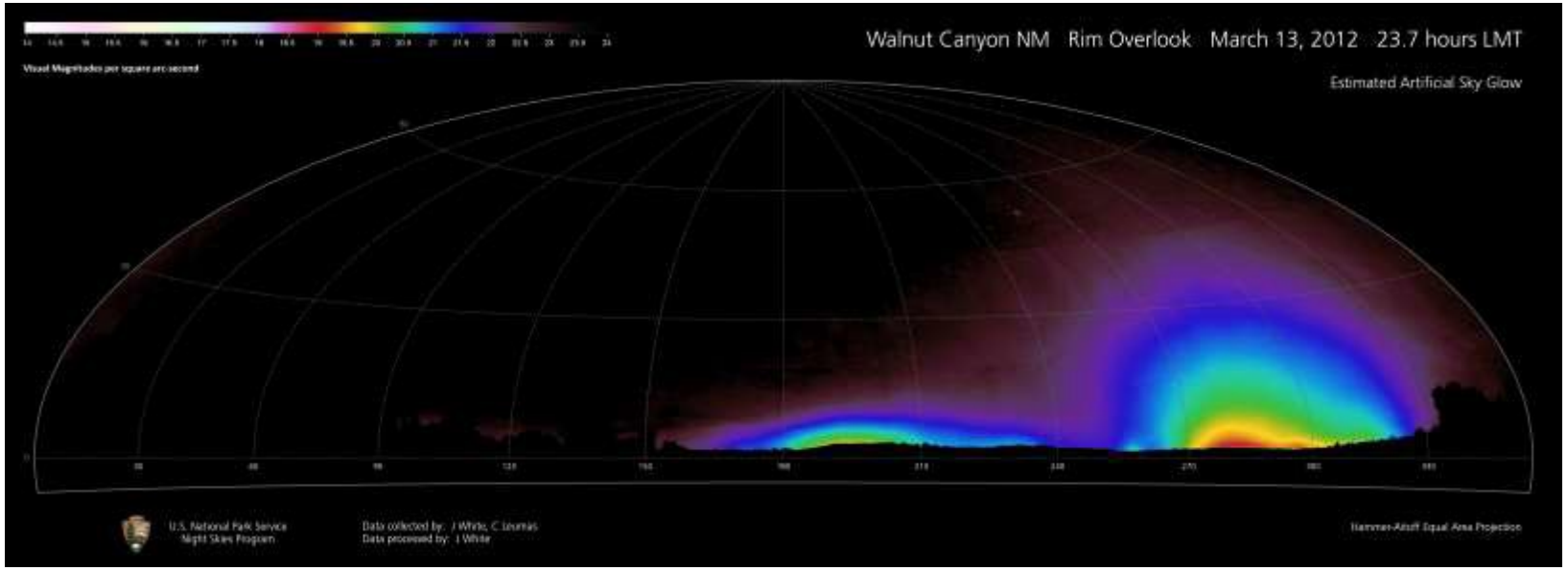
Average Sky Luminance (mag arcsec^{-2})	Average Sky Luminance (µcd/m^2)	Zenith Luminance (mag arcsec^{-2})	Zenith Luminance (µcd/m^2)	Brightest luminance (mag arcsec^{-2})	Brightest lumininance	Synthetic SQM (mag arcsec^{-2})	Total luminous emittance (mags)	Illuminance (mlux)	
								Horizontal	Max Vert
21.11	389	21.71	224	16.64	24,002	21.51	-7.35	0.988	0.869





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 lumininance	Synthetic SQM (mag arcsec^{-2})	Total luminous emittance (mags)	Illuminance (mlux)	
								Horizontal	Max Vert
21.14	381	21.74	219	16.67	23,373	21.54	-7.33	0.963	0.849



NPS NIGHT SKIES PROGRAM DATA NIGHT REPORT

SUCR120314 Sunsect Crater NM **Lava Flow Parking Lot** **14-Mar-12**

Data Night Attributes

Longitude:	-111.51872	Camera:	IMG 2	Air temp. (C):	8.7	ZLM:	6.80	OBS_1:	J White
Latitude:	35.36256	# of sets:	7	R. H. (%):	14.0	BORTLE:	3	OBS_2:	C Leumas
Elevation (m):	2125	Exposure (secs):	14	Wind Speed (mph):	1	SQM:	21.77	OBS_3:	

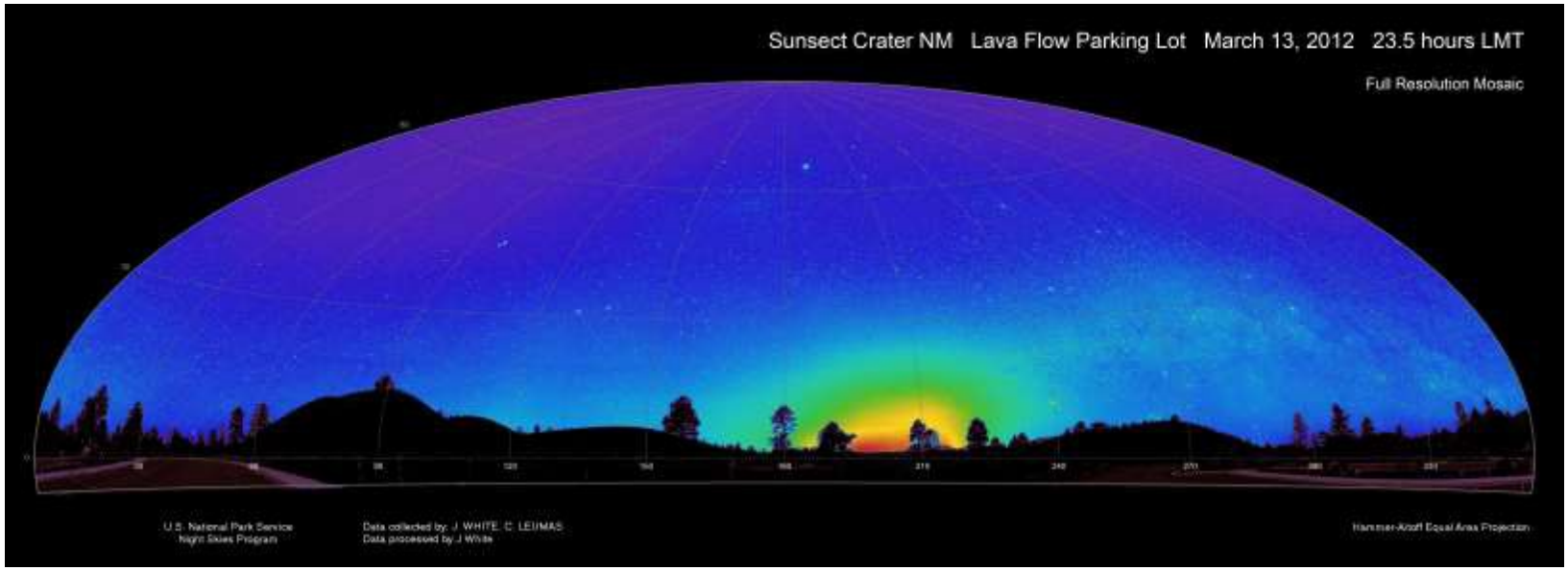
NARRATIVE: Sky was fairly bright with Mars Venus and Jupiter all up. Milky Way band was visible but very fine details were not visible towards the Flagstaff lightdome. More detail overhead and to the north. Uniform darkess at Zenith down to ZA30. Bright Airglow visible, especially sillouted against Sunset Crater. SQM of 21.77 and SQM-L 21.67. No Clouds by the time we got to SUCR from WACA. Transparency very good, seeing was fair.

Data Set Attributes

	Quality Flags				Natural Sky Model			Extinction				Collection Properties			
Data Set	Use-able	Col-lection	Pro-cessing	Atmo-sphere:	Zenith airglow (µcd/m²)	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	111	5	Moderate smooth airglow visible, good subtraction	0.178	0.04	94	3	0	0.21	0.33	4.9
2	Y	5	5	4	102	5	Moderate smooth airglow visible, good subtraction	0.178	0.04	99	3	0	0.23	0.35	5.5
3	Y	5	5	4	99	5	Moderate smooth airglow visible, good subtraction	0.179	0.04	101	2	0	0.23	0.34	4.3
4	Y	5	5	4	95	5	Moderate smooth airglow visible, good subtraction	0.174	0.04	100	1	0	0.24	0.36	4.8
5	Y	5	5	4	95	5	Moderate smooth airglow visible, good subtraction	0.169	0.04	96	0	0	0.25	0.36	6.8
6	Y	5	5	4	99	5	Moderate smooth airglow visible, good subtraction	0.170	0.04	93	0	0	0.25	0.36	3.3
7	N	1	4	4	175	1	Issue with last set, do not use	0.172	0.04	96	1	0	0.25	0.36	8.7

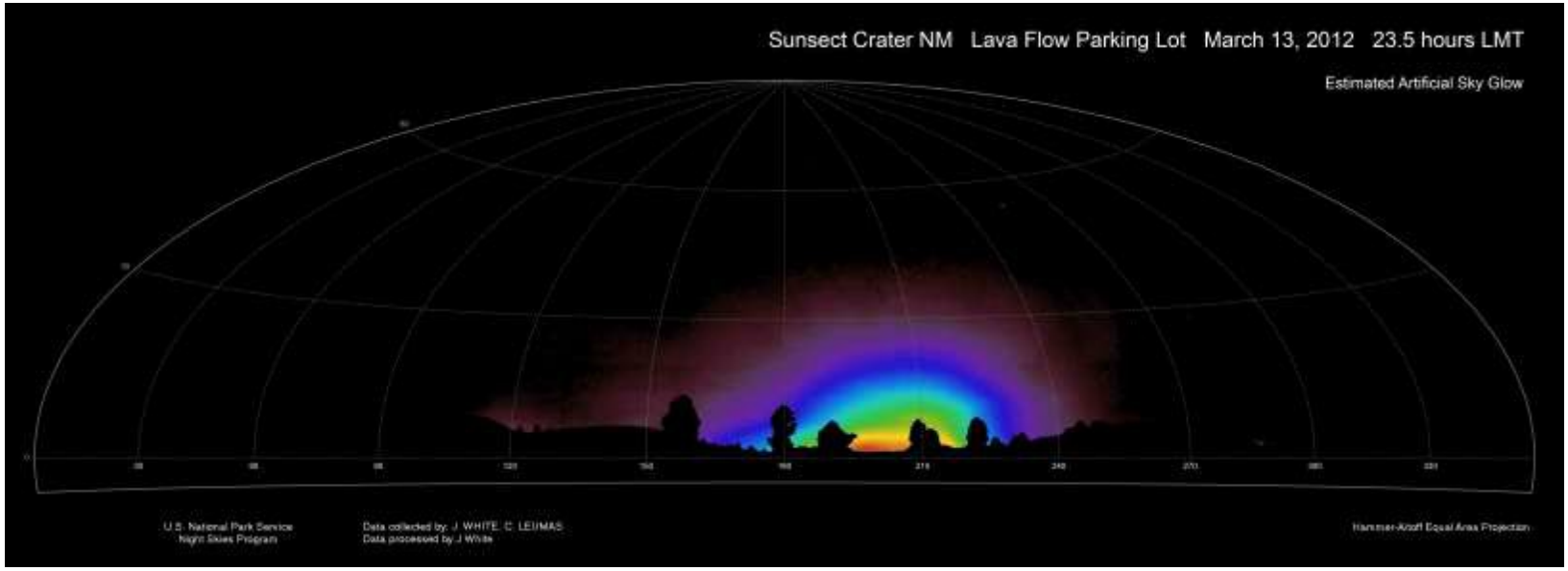
Populated Places

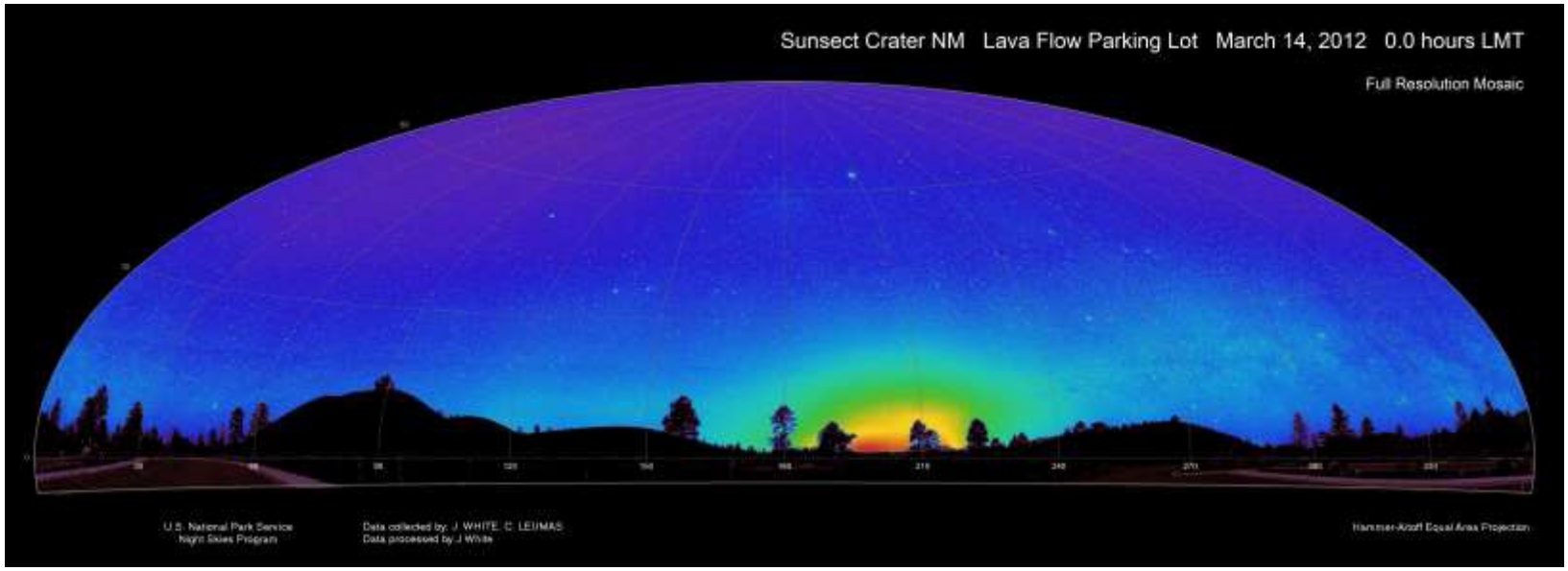
Place	Population (2010)	Distance (km)	Azimuth	Walker's	Apparent Half-Width (degrees)
Flagstaff city	65,870	21.8	205	2.979	18.4
Doney Park CDP	5,395	10.5	173	1.509	18.5
Phoenix city	1,445,632	205.7	195	0.238	5.7
Mesa city	439,041	218.6	185	0.062	2.8
Scottsdale city	217,385	190.3	189	0.044	3.7
Kachina Village CDP	2,622	33.9	208	0.039	1.7
Glendale city	226,721	212.4	197	0.034	1.9
Sedona city	10,031	61.5	204	0.034	3.7
Fort Valley CDP	779	22.2	238	0.034	6.5
Peoria city	154,065	189.4	203	0.031	3.6
Prescott Valley town	38,822	111.7	221	0.029	2.9
Chandler city	236,123	233.1	188	0.028	1.8
Gilbert town	208,453	229.0	185	0.026	1.9
Las Vegas city	583,756	351.0	287	0.025	1.7
Prescott city	39,843	121.4	224	0.025	2.8
Tempe city	161,719	222.6	190	0.022	1.5
Tucson city	520,116	361.5	170	0.021	2.2
Mountainaire CDP	1,119	32.0	201	0.019	5.2
Surprise city	117,517	206.5	205	0.019	2.6
Verde Village CDP	11,605	84.2	211	0.018	1.6
Cottonwood city	11,265	83.8	212	0.018	2.5
Village of Oak Creek (Big Pa	6,147	68.2	199	0.016	1.7
Winslow city	9,655	82.5	117	0.016	2.2
Henderson city	257,729	325.7	284	0.013	1.7
Albuquerque city	545,852	443.0	92	0.013	1.6
Camp Verde town	10,873	93.4	199	0.013	3.7
Tuba City CDP	8,611	88.2	16	0.012	1.8
Paradise CDP	223,167	336.0	285	0.011	1.1



PHOTOMETRY OF ALL SOURCES

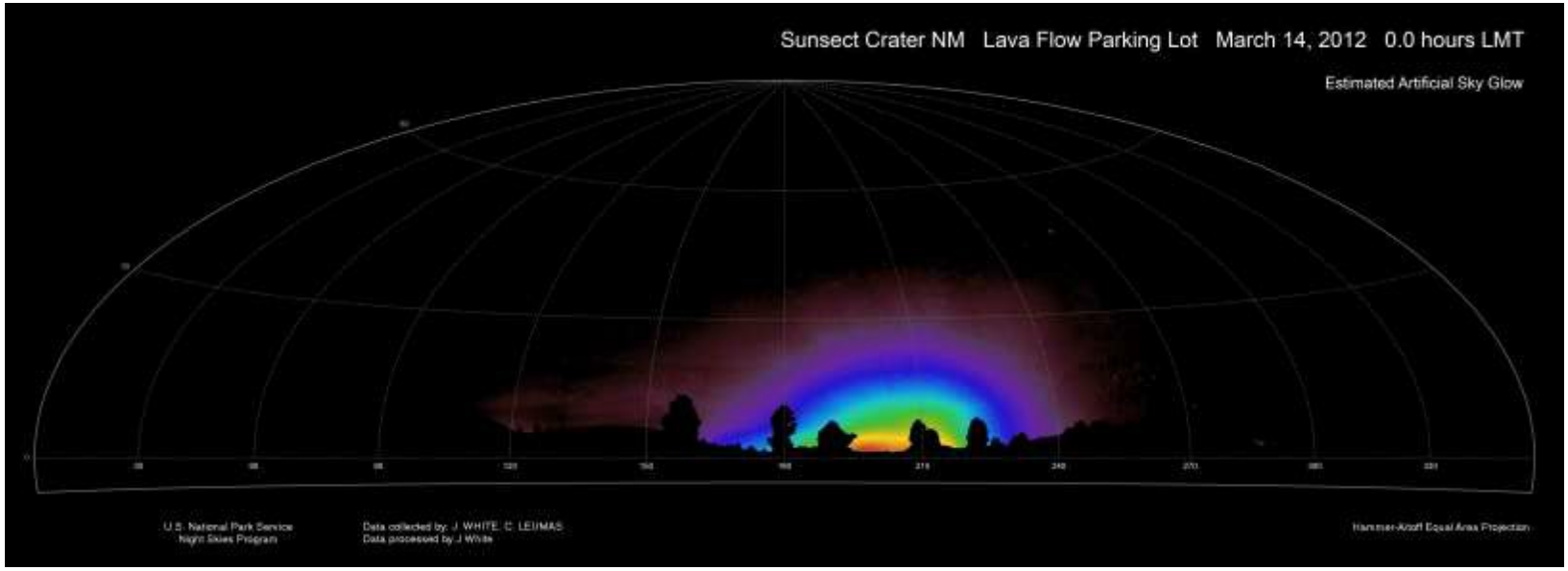
Average Sky Luminance (mag arcsec^{-2})	Average Sky Luminance (µcd/m^2)	Zenith Luminance (mag arcsec^{-2})	Zenith Luminance (µcd/m^2)	Brightest luminance (mag arcsec^{-2})	Brightest lumininance	Synthetic SQM (mag arcsec^{-2})	Total luminous emittance (mags)	Illuminance (mlux)	
								Horizontal	Max Vert
21.32	322	21.79	209	18.98	2,780	21.63	-7.15	0.861	0.635





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 lumininance	Synthetic SQM (mag arcsec^{-2})	Total luminous emittance (mags)	Illuminance (mlux)	
								Horizontal	Max Vert
21.32	322	21.79	209	19.00	2,721	21.63	-7.15	0.861	0.629



NPS NIGHT SKIES PROGRAM DATA NIGHT REPORT

WUPA120315A Wupatki National Monument **Wukoki Ruin** **15-Mar-12**

Data Night Attributes

Longitude:	-111.32772	Camera:	IMG 1	Air temp. (C):	13.9	ZLM:	6.80	OBS_1:	J White
Latitude:	35.52960	# of sets:	7	R. H. (%):	13.4	BORTLE:	2	OBS_2:	C Leumas
Elevation (m):	1412	Exposure (secs):	12	Wind Speed (mph):	2	SQM:	21.77	OBS_3:	

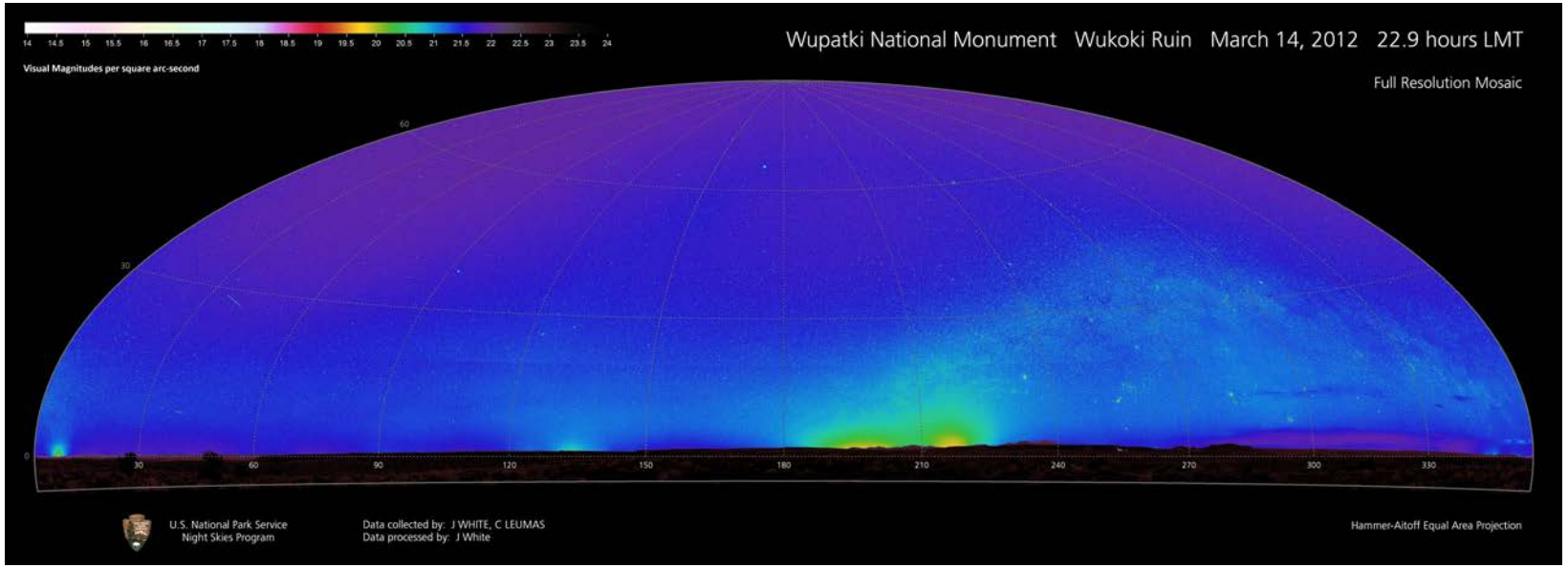
NARRATIVE: Clouds low on the horizon to the northwest. Overall transparency is average with visible haze along a band up to 5 degrees above horizon. There is a dark uniform sky at zenith. Seeing is fair. Milky Way is visible past sirius to the south and through cassipoeia to the north. Low airglow through the night, and very little change in atmosphere over the course of 8 sets. SQM was 21.77.

Data Set Attributes

	Quality Flags				Natural Sky Model			Extinction				Collection Properties			
Data Set	Use-able	Col-lection	Pro-cessing	Atmo-sphere:	Zenith airglow (µcd/m²)	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	73	5	Excellent subtraction, very good night	0.186	0.04	74	3	2	0.30	0.37	7.3
2	Y	5	5	4	73	5	Excellent subtraction, very good night	0.188	0.04	78	4	1	0.29	0.35	10.4
3	Y	5	5	4	76	5	Excellent subtraction, very good night	0.188	0.04	86	3	1	0.29	0.35	9.1
4	Y	5	5	4	76	5	Excellent subtraction, very good night	0.187	0.04	75	3	1	0.27	0.33	7.9
5	Y	5	5	4	80	5	Excellent subtraction, very good night	0.186	0.04	82	4	1	0.27	0.33	8.3
6	Y	5	5	4	80	5	Excellent subtraction, very good night	0.185	0.04	80	7	1	0.26	0.33	8.1
7	Y	5	5	4	83	4	Excellent subtraction, very good night	0.188	0.04	80	3	1	0.25	0.32	5.7

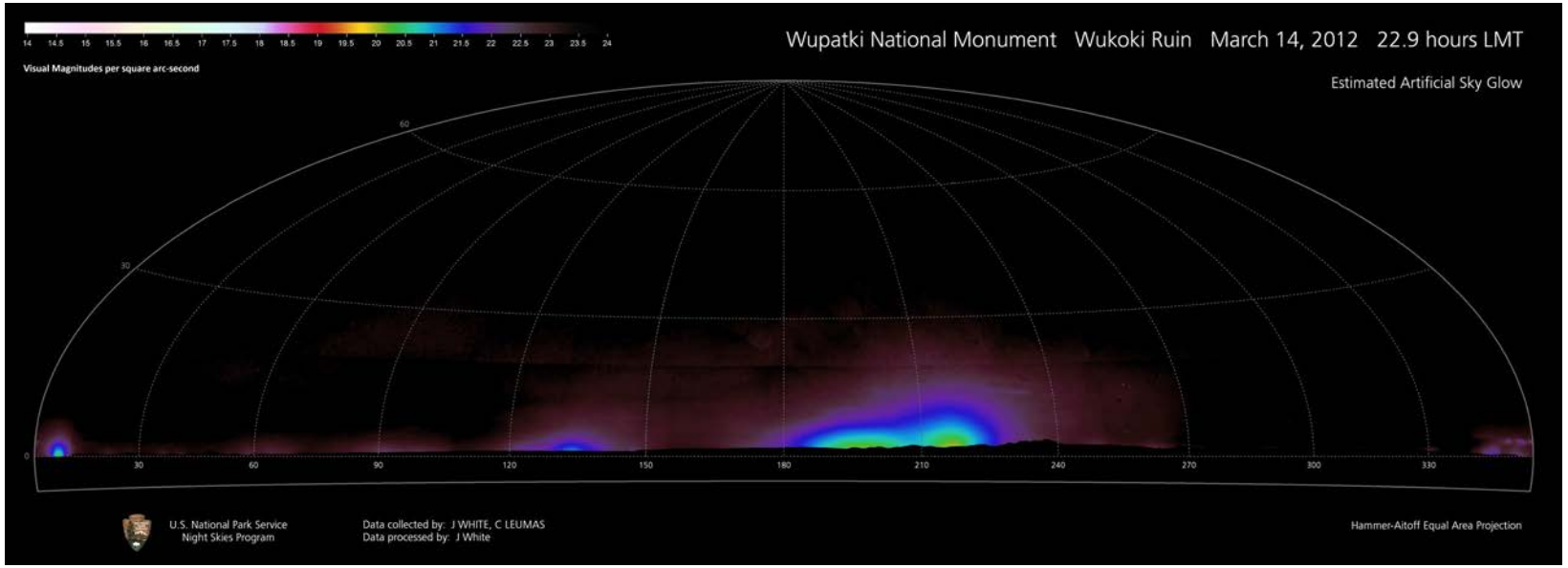
Populated Places

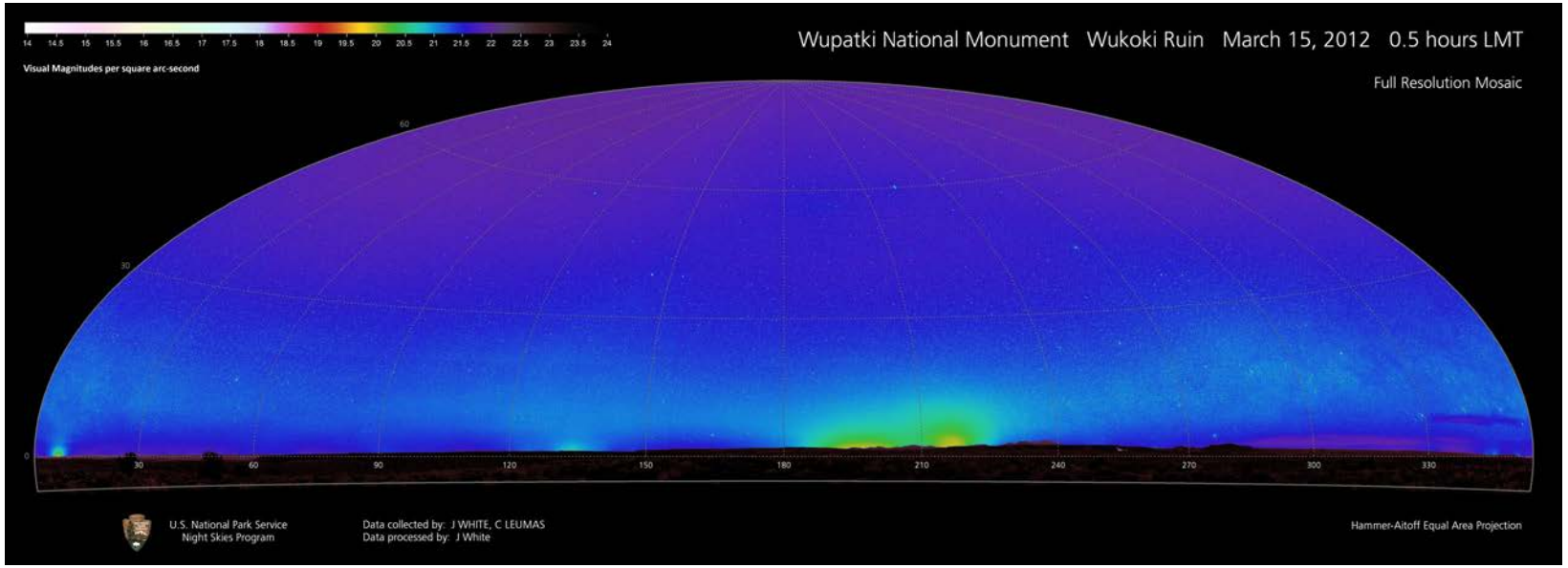
Place	Population (2010)	Distance (km)	Azimuth	Walker's	Apparent Half-Width (degrees)
Flagstaff city	65,870	46.6	215	0.445	8.9
Phoenix city	1,445,632	228.4	198	0.183	5.2
Doney Park CDP	5,395	33.2	209	0.085	6.0
Mesa city	439,041	239.1	189	0.050	2.5
Scottsdale city	217,385	211.7	193	0.033	3.3
Glendale city	226,721	235.5	200	0.027	1.7
Tuba City CDP	8,611	66.6	6	0.024	2.3
Las Vegas city	583,756	362.8	283	0.023	1.7
Peoria city	154,065	213.4	205	0.023	3.2
Chandler city	236,123	254.3	191	0.023	1.6
Gilbert town	208,453	249.5	189	0.021	1.7
Tucson city	520,116	377.4	173	0.019	2.1
Prescott Valley town	38,822	137.1	221	0.018	2.4
Tempe city	161,719	244.3	193	0.017	1.3
Winslow city	9,655	79.3	135	0.017	2.3
Prescott city	39,843	146.8	224	0.015	2.3
Sedona city	10,031	85.9	210	0.015	2.6
Surprise city	117,517	230.8	207	0.015	2.3
Albuquerque city	545,852	426.9	95	0.014	1.7
Henderson city	257,729	338.7	280	0.012	1.6
Cameron CDP	885	37.1	346	0.011	6.1
Leupp CDP	951	39.2	131	0.010	4.9
Kachina Village CDP	2,622	58.8	214	0.010	1.0
Paradise CDP	223,167	348.7	281	0.010	1.0
North Las Vegas city	216,961	348.7	285	0.010	1.5
Verde Village CDP	11,605	109.2	214	0.009	1.3
Cottonwood city	11,265	108.8	214	0.009	1.9
Sunrise Manor CDP	189,372	342.8	283	0.009	0.9



PHOTOMETRY OF ALL SOURCES

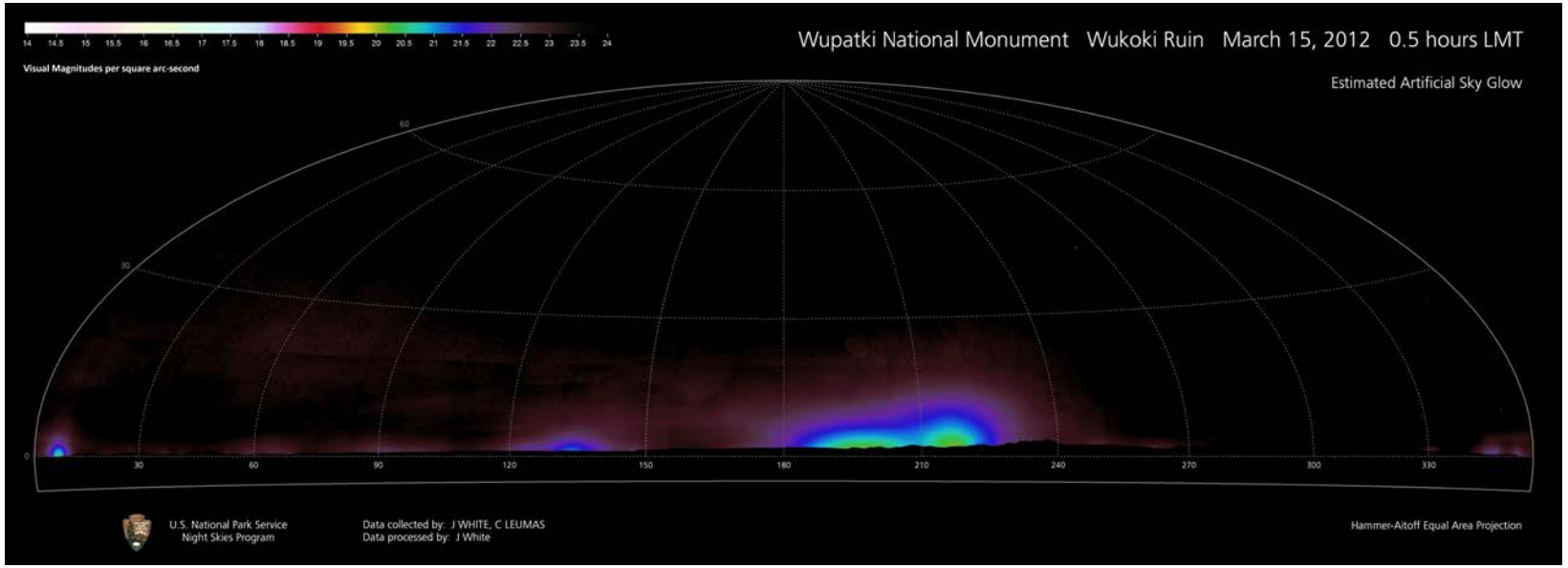
Average Sky Luminance (mag arcsec^{-2})	Average Sky Luminance (µcd/m^2)	Zenith Luminance (mag arcsec^{-2})	Zenith Luminance (µcd/m^2)	Brightest luminance (mag arcsec^{-2})	Brightest lumininance	Synthetic SQM (mag arcsec^{-2})	Total luminous emittance (mags)	Illuminance (mlux) Horizontal	Max Vert
21.49	274	21.92	185	19.86	1,233	21.74	-7.06	0.763	0.511





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 lumininance	Synthetic SQM (mag arcsec^{-2})	Total luminous emittance (mags)	Illuminance (mlux)	
								Horizontal	Max Vert
21.50	273	21.95	179	19.96	1,128	21.77	-7.06	0.751	0.488



Long Term Monitoring

Management and staff of the Flagstaff Area National Monuments are committed to collecting long-term sky quality measurements. An administrative record for collection of night skies data already exists at the monuments. The NPS Night Skies Team has visited each monument three times in the last 10 years. This gives an excellent set of data to reference dating from 2002 to 2012, plus ongoing data collected by the monuments' staff.

NPS staff has purchased three basic Unihedron Sky Quality Meter devices to be shared among the monuments and has created a data collection form to support long-term sky quality data collection. Staff will collect data at each of the monuments collection sites at minimum once per year, and will collect additional measurements as weather and sky conditions allow. The sites where data are collected will remain constant, revisiting the sites previously used for data collection by the NPS Night Skies team.

Visitor Experience

Night Sky Programs and Educational Outreach at the Flagstaff Area National Monuments (Walnut Canyon, Sunset Crater Volcano and Wupatki National Monuments)

The Flagstaff Area National Monuments are an ideal place for star gazing, learning about astronomy related subjects, and demonstrating the importance of preserving dark night skies. Visitors have the opportunity to see examples of how lighting codes and practices have significantly reduced sky glow. At star parties and astronomy programs, visitors meet at facilities that have been retrofitted with "night sky friendly" lighting and interpreters share the success stories of retrofits around the monuments. These publicly visible facilities are also interpreted in the daytime through displays and interpretation programs. Local efforts in preserving dark night skies set an important example for other cities, organizations, and individuals. Visitors to the monuments have exceptional opportunities to witness starry skies and learn about how they can make a difference protecting our dark skies.

The Flagstaff Area National Monuments' astronomy program has three telescopes, two solar scopes, two sky quality meters, and a multitude of night sky interpretive material. Rangers receive night sky training and have a number of resources at their disposal for self-education. During night sky events, rangers and participants record sky quality data and use the data as another tool to educate the public on the quality of dark skies. The monuments partner with the city of Flagstaff, the Verde Valley Astronomy Club (a member of the NPS Astro Volunteer-in-Park, or VIP program), Lowell Observatory, the Coconino National Forest, and local astronomy volunteers. The Flagstaff Area National Monuments have been conducting night sky programs for several years and are dedicated to educating visitors and conducting local outreach. Night sky interpretation for the monuments has included, but is not limited to the following:

- At least three annual star parties are conducted with the support of the Verde Valley Astronomy Club. On average there are seven to eight scopes available for viewing, a slide presentation and constellation tours. These are commonly the most well attended programs in the park with attendance of programs ranging from 50-100 attendees.

- Through a partnership with the Coconino National Forest, evening programs are regularly delivered in nearby US Forest Service campgrounds on night sky topics, throughout the summer season.

- Nighttime and full moon guided walks are offered in the monuments.

- During the city's "Lights Out Flagstaff" event, the monuments partner with the local state government by providing constellation talks in nearby city parks and discussing the importance of maintaining dark skies.

- Throughout the summer, the monuments have solar viewing demonstration talks.

- The monuments have hosted eclipse viewings.

- Partnering with the city of Flagstaff during the "Festival of Science" in 2015, approximately

1300 people were contacted by rangers during their night sky program held at a local Flagstaff city park.

- Special talks are provided for the city's annual "Festival of Science", such as "Moonscape Adventures" a presentation and guided walk discussing the monuments' role in the Apollo astronaut's training for the nation's moon landings.

Overall, the Flagstaff National Monuments' are an exceptional place to experience and learn about the night sky. Our connection to the City of Flagstaff is also a great opportunity to expand education in the community and to demonstrate that we continue to be dedicated to preserving and protecting all of the monuments' resources. We believe that in becoming an International Dark Sky park that we'll be continuing our mission to leave our resources unimpaired for future generations and demonstrating to our neighboring communities our commitment to preserving dark night skies and its utmost importance.

Astronomy program at Sunset Crater Volcano
NPS Photo

Web Presence

Currently, web presence is limited to information regarding night sky programs. A combined page linked to each of the monuments websites is currently being created to detail the importance of the night skies along with updates on the latest night sky programs. In December 2015, the Flagstaff Area National Monuments Social Media Plan was approved, allowing monuments to reach an even greater audience through social media outlets such as Facebook and Flicker. Night Sky themes appear as part of the monuments social media messaging.

Wupatki National Monument
Page Liked · December 15, 2015 · Edited ·

We don't exactly have a marching band for the #RoseParade, but we sure have some beautiful stars marching across our dark sky. Do they count? Welcome to Wupatki National Monument's Facebook page and our first-ever post, Everyone! #FindYourPark -cg

Example social media post

Poster advertising astronomy programs at Sunset Crater Volcano

2 Park Lighting Inventory

Lomaki Pueblo, Wupatki
Photo/Stan Honda

Overview

The Flagstaff Area National Monuments have actively worked to protect the natural nighttime environment by setting a leadership example in the restoration of dark skies in the full implementation of the retrofit project of the monuments' exterior lighting. To this end, artificial lighting exists at a minimum level. Decisions on lighting will continue to be made by considering many factors and utilizing the appropriate amount of light necessary. The vast majority of the land within the monuments contains no artificial lighting, including all areas where there is a visitor expectation for darkness, such as parking areas, trails, and wilderness-managed areas. There is zero artificial lighting within the legislative boundary of Sunset Crater Volcano. All exterior lights under the 'Sunset Crater Volcano' section are on NPS structures located on US Forest Service land. FLAG has assisted the Coconino National Forest by providing guidance for dark sky retrofits at their Bonito Campground, very near Sunset Crater Volcano.

This lighting inventory is a result of efforts by the Flagstaff Area National Monuments staff from 2013-2015. Any fixtures not yet conforming to the Lighting Management Plan are scheduled to be replaced as described in 2016 and FLAG is committed to maintaining 100% compliance for perpetuity. The lighting inventory is organized by monument. The following pages list a detailed summary of lighting fixtures and characteristics in the park. At this time, a vast majority of park lighting is compliant.

This table summarizes the current status of lighting compliance as of January 1, 2016.

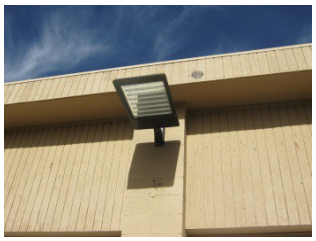
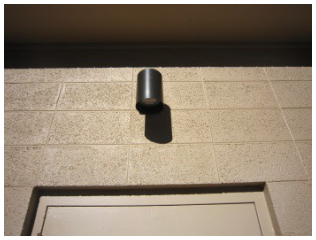
	# lights	# comply	# not-comply	% compliance
Walnut Canyon	**35**	**26**	**9**	**74.3%**
Sunset Crater	**41**	**41**	**0**	**100.0%**
Wupatki	**33**	**32**	**1**	**97.0%**
Total (Jan 2016)	**109**	**99**	**10**	**90.8%**

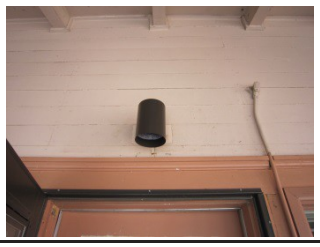
Lighting Inventory—Walnut Canyon

Total lights: 35
Total in compliance:26
Total not in compliance: 9

ID #	Description/ Purpose	Specifications/ Technical Info	Fully Shielded?	Complies with LMP?	Mitigation/Notes
1	CCC Restroom, egress	historic fixture, switch	No	No	Light currently not in use, retrofit needed
2	CCC Restroom, egress	historic fixture, switch	No	No	Light currently not in use, retrofit needed
3	Kiosk, flashing amber caution	post mounted, other, LED, 13 w, switch	Partial	Yes	In compliance, not operated at night
4	Kiosk, flashing red stop	post mounted, other, LED, 13 w, switch	Partial	Yes	In compliance, not operated at night
5	Maintenance shop, PV LED	wall area, LED, 40 w, 1200 lumens, timer	Full	Yes	Fully shielded shoebox fixture installed in 2013
6	Maintenance shop, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
7	Pinion House front entrance, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
8	Pinion House side entrance, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
9	Pinion House back entrance, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
10	Ponderosa House front entrance, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
11	Ponderosa House side entrance, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
12	Ponderosa House back entrance, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
13	Residence 1 side entrance, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
14	Residence 1 back porch, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
15	Residence 1 front garage, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015

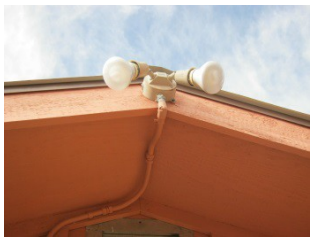
Lighting Inventory—**Walnut Canyon** (continued)					
16	Residence 2 back garage, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
17	Residence 2 front porch, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
18	Residence 2 back porch, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
19	Residence 2 third, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
20	Residence 2 front garage, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
21	Residence 2 back garage, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
22	Visitor Center front porch, area	globe, switch	Canopy partial	No	Light currently not in use, retrofit needed
23	Visitor Center front porch, area	globe, switch	Canopy partial	No	Light currently not in use, retrofit needed
24	Visitor Center front porch, area	globe, switch	Canopy partial	No	Light currently not in use, retrofit needed
25	Visitor Center front porch, area	globe, switch	Canopy partial	No	Light currently not in use, retrofit needed
26	Visitor Center front porch, area	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	In compliance
27	Visitor Center front porch, area	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	In compliance
28	Visitor Center front porch, area	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	In compliance
29	Visitor Center back porch, area	historic fixture, switch	Canopy partial	No	
30	Visitor Center back porch, area	historic fixture, switch	Canopy partial	No	
31	Visitor Center side entrance, egress	Incandescent	No	No	Replace with Amber LED
32	Well House, egress	wall cannister, amber LED, 8 w, 175 lumens, switch		Yes	Permanently removed
33	Well House, egress	Flood lights		Yes	Permanently removed
34	Maintenance Shop Drive, area	Pole mounted high pressure sodium	No	Yes	Permanently disabled
35	Vending Machine	vending machine lights	Full	Yes	Lights disabled

Luminaire Image Index—**Walnut Canyon**		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
1		**replace with fully shielded**
2		**replace with fully shielded**
3		**in compliance**
4		**in compliance**
5	*no before picture*	
6		
7		

Luminaire Image Index—**Walnut Canyon** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
8		
9		
10		
11		
12		
13		
14		

Luminaire Image Index—**Walnut Canyon** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
15	*no before picture*	
16	*no before picture*	
17		
18		
19		
20	*no before picture*	
21	*no before picture*	

Luminaire Image Index—**Walnut Canyon** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
22		**replace with fully shielded**
23		**replace with fully shielded**
24		**replace with fully shielded**
25		**replace with fully shielded**
26		**in compliance**
27		**in compliance**

Luminaire Image Index—**Walnut Canyon** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
28		**in compliance**
29		**replace with fully shielded**
30		**replace with fully shielded**
31		**replace with fully shielded**
32		
33		

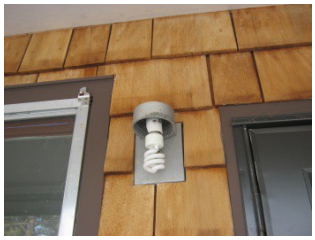
Luminaire Image Index— **Sunset Crater Volcano**		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
34		**in compliance**
35		**in compliance**

Lighting Inventory—Sunset Crater Volcano

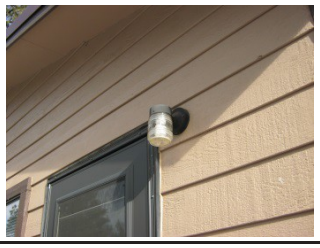
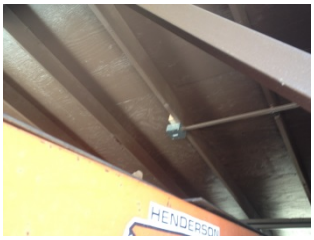
Total lights: 41
Total in compliance: 41
Total not in compliance: 0

ID #	Description/ Purpose	Specifications/ Technical Info	Fully Shielded?	Complies with LMP?	Mitigation/Notes
36	Apt A Front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
37	Apt A Back, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
38	Apt B front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
39	Apt B back, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
40	Apts laundy room, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
41	Fire cache, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
42	Maintenance garage, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
43	Maintenance office front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
44	Maintenance office side, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
45	Maintenance shop north, area		N/A	Yes	Permanently removed 2015
46	Maintenance shop south, area		N/A	Yes	Permanently removed 2015
47	Res 7 front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
48	Res 7 side, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
49	Res 7 back, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014

Lighting Inventory—**Sunset Crater Volcano** (continued)					
50	Res 7 garage, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
51	Res 2 front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
52	Res 2 side, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
53	Res 2 back, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
54	Res 2 garage, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2015
55	Truck bay, area	Incandesent interior light	Partial	Yes	Replaced 2015
56	VC back entrance, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
57	VC mechanical entrance, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
58	VC front globes (7)	historic globes (7), diab	No	Yes	Permanently disabled 2015
59	VC bollards (5)	bollards (5)	No	Yes	Permanently disabled 2015
60	Weights garage, egress	wall cannister, amber LED, 8 w, 175 lumens	Full	Yes	Canister was installed 2014
61	Kiosk post amber, caution	post mounted, other, LED, 13 w	Partial	Yes	
62	kiosk post red, stop	post mounted, other, LED, 13 w	Partial	Yes	
63	kiosk entrance, egress	wall cannister, amber LED, 8 w, 175 lumens	N/A	Yes	Permanently Removed 2015
64	kiosk front, area	flood lights	N/A	Yes	Permanently removed 2015
65	well house, egress	wall cannister, amber LED, 8 w, 175 lumens	Full	Yes	Canister was installed 2014
66	Vending machine	vending machine lights	Canopy partial	Yes	Lights disabled

Luminaire Image Index— **Sunset Crater Volcano**		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
36		
37		
38		
39		
40		
41		
42		

Luminaire Image Index— **Sunset Crater Volcano** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
43		
44		
45		
46		
47		
48		
49	*no before picture*	

Luminaire Image Index— **Sunset Crater Volcano** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
50		
51		
52		
53		
54		
55		
56		

Luminaire Image Index— **Sunset Crater Volcano** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
57		
58		**in compliance**
59		**in compliance, to be upgraded**
60		
61		**in compliance**
62		**in compliance**

ID #	“Before” photo—existing luminaire	Photo after mitigation (if needed)
63		
64		
65		
66		in compliance

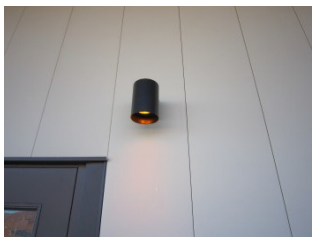
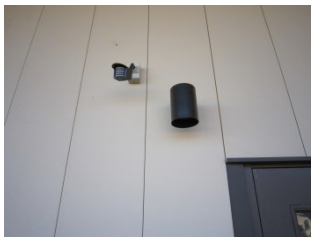
Lighting Inventory—Wupatki

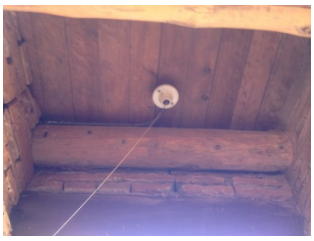
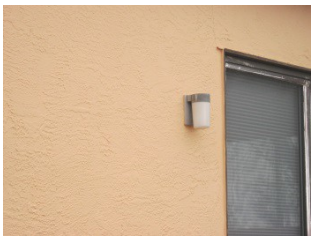
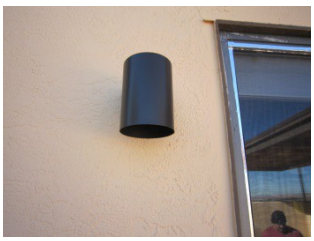
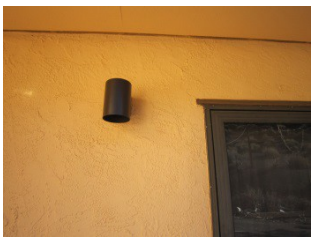
Total lights: 33
Total in compliance: 32
Total not in compliance: 1

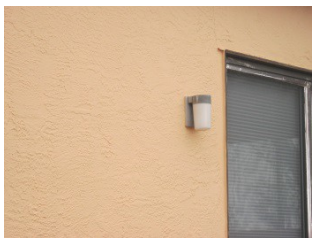
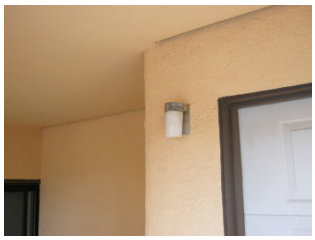
ID #	Description/ Purpose	Specifications/ Technical Info	Fully Shielded?	Complies with LMP?	Mitigation/Notes
67	Apt 13 front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
68	Apt 11 front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
69	Apt 9 front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
70	Apt 7 front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
71	Apt 7 back, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
72	Apt 9 back, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
73	Apt 11 back, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
74	Apt 13 back, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
75	Apt laundary, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
76	Maintenance shop front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
77	Maintenance shop side, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
78	New hesier 1, egress	wall cannister, amber LED, 8 w, 175 lumens, motion	Full	Yes	Canister was installed 2014
79	New heiser 2, egress	wall cannister, amber LED, 8 w, 175 lumens, motion	Full	Yes	Canister was installed 2014

Lighting Inventory—**Wupatki** (continued)					
80	Res 1 garage, egress		N/A	Yes	Bulb removed
81	Res 1 hall, egress		N/A	Yes	Bulb removed
82	Res 1 front, egress		N/A	Yes	Bulb removed
83	Res 1 back, egress		N/A	No	Bulb to be removed
84	Res 1 side, egress		N/A	Yes	Bulb removed
85	Res 10 front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
86	Res 10 garage, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
87	Res 10 side, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
88	Res 10 back, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
89	Res 12 front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
90	Res 12 garage, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
91	Res 12 side, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
92	Res 12 back, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
93	VC east front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
94	VC west front, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
95	VC back inside, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
96	VC back outside, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
97	VC side, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
98	Well house, egress	wall cannister, amber LED, 8 w, 175 lumens, switch	Full	Yes	Canister was installed 2014
99	Vending machine	other	Full	Yes	Lights disabled

Luminaire Image Index—**Wupatki**		
ID #	**“Before” photo—existing luminaire**	**Photo after mitigation (if needed)**
67		
68		
69		
70		
71		
72		
73		

Luminaire Image Index—**Wupatki** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
74		
75		
76		
77		
78		
79		
80		

Luminaire Image Index—**Wupatki** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
81		
82		
83		**Remove bulb**
84		
85		
86		
87		

Luminaire Image Index—**Wupatki** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
88		
89		
90		
91		
92		
93		

Luminaire Image Index—**Wupatki** (continued)		
ID #	**"Before" photo—existing luminaire**	**Photo after mitigation (if needed)**
94		
95		
96		
97		
98		
99		**in compliance**

3 Management Documents

Sunset Crater Volcano
Photo/Kyle Ackerman

NPS Management Policies

An assortment of laws and directives at the federal and park level serve as guidelines for the Flagstaff Area National Monuments in its mission to protect natural night skies. From the 1916 Organic Act to the Lightscape Management Plan in 2006, the federal government has laid out a basis for the idea of protecting night skies. In addition to these, the Director's Call to Action Report 2012, Action 27, reaffirms the National Park Service's support towards the protection of dark sky resources. The Foundation Documents of each of the Flagstaff Area National Monuments provides further guidance and approval for the extension of park protection of the night skies.

National Park Service Organic Act

The Organic Act was passed in 1916 to protect and manage the national park lands of the United States. The act protects the ecological and scenic values within federal lands, under which fall dark sky resources.

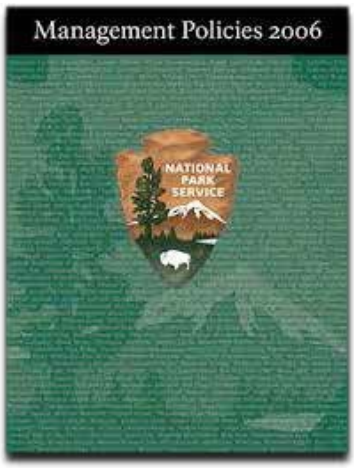
"The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of futuregenerations."

4.10 Lightscape Management (2006)

This service-wide document of management policies provides the National Park Service with required and recommended actions to manage programs and parks. Included within is a Lightscape Management Plan, which lays out specific guidelines and recommendations for light management and use.

"The Service will preserve, to the greatest extent possible, the natural lightscapes of parks, which are natural resources and values that exist in the absence of human caused light....The stars, planets, and earth's moon that are visible during clear nights influence humans and many other species of animals, such as birds that navigate by the stars or prey animals that reduce their activities during moonlight nights."

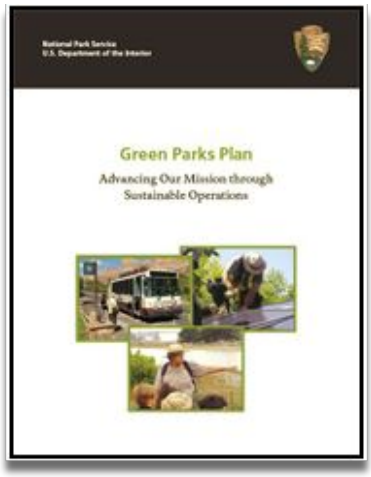
"Improper outdoor lighting can impede the view and visitor enjoyment of a natural dark night sky. Recognizing the roles that light and dark periods and darkness play in natural resource processes and the evolution of species, the Service will protect natural darkness and other components of the natural lightscape in parks. To prevent the loss of dark conditions and of natural night skies, the Service will minimize light that emanates from park facilities, and also seek the cooperation of park visitors, neighbors, and local government agencies to prevent or minimize the intrusion of artificial light into the night scene of the ecosystems of parks. The Service will not use artificial lighting in areas such as sea turtle nesting locations where the presence of the artificial lighting will disrupt a park's dark-dependent natural resource components."



The Service will:

- restrict the use of artificial lighting in parks to those areas where security, basic human safety, and specific cultural resource requirements must be met;
- use minimal-impact lighting techniques;
- shield the use of artificial lighting where necessary to prevent the disruption of the night sky, natural cave processes."

The Green Parks Plan 4/2012



The Green Parks Plan is a long-term strategic plan for management of NPS operations in a sustainable manner.

"The NPS will minimize the impact of facility operations on the external environment. Outdoor experiences can be adversely affected by facility operations. Exterior lighting can reduce dark night sky quality and vehicle traffic can diminish the natural silence and sounds of an ecosystem. Reducing the impact of NPS operations on the environment will improve the visitor experience and protect natural and cultural resources through the preservation of night skies, natural sounds, water quality, ecosystems, and viewsheds."

"Objectives
1: The NPS will reduce light pollution from park facilities with the goal of dark night sky preservation.
2: The NPS will minimize sound pollution in the outdoor environment.
3: The NPS will ensure that all facilities and operations are sustainably integrated into the park landscape to minimize impact on the natural and cultural environment."

Night Sky Management

Natural Sounds and Night Skies

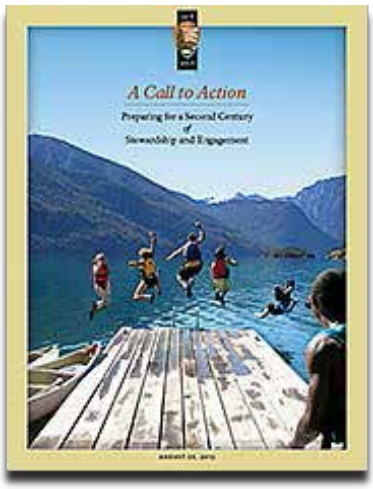
"America's national parks contain many cherished treasures; among them are captivating natural sounds and awe-inspiring night skies. The joy of listening to the quiet symphony of nature or the beauty of seeing the Milky Way stretching overhead have become rare experiences in our lifetimes, but they can still be found in many of our national parks. Natural sounds and natural darkness, though often overlooked, are essential in keeping our national treasures whole. They are magnificent in their own right, but also inspirational to the visitors who come to national parks, vital to the protection of wilderness character, fundamental to the historical and cultural context, and critical for park wildlife."

"The Natural Sounds and Night Skies Division uses science, engineering, and technology to understand and better manage these spectacular resources. We pioneer innovative techniques to measure the impact of noise and light pollution, develop new approaches to safeguard natural sounds and natural darkness, and identify management solutions to restore these public resources."

"The Natural Sounds and Night Skies Division works to protect, maintain, or restore acoustical and dark night sky environments throughout the National Park System. We work in partnership with parks and others to increase scientific understanding and inspire public appreciation of the value and

character of soundscapes and star-filled skies. We welcome your interest in learning about these sublime resources of our national parks and the efforts you can take to help us preserve them for future generations. Whether it's simply talking a little softer or turning off an outdoor light, you too can make a difference in the protection of these vital resources. Most of all, we encourage you to experience for yourself the natural soundscapes and lightscapes of your national parks."

The Director's Call to Action Report 2012



The Director's Call to Action Report is a guideline for employees and partners that contains specific goals and measurable actions, and charts a path towards unified goals.

"Starry, Starry Night: Action 27"
Lead the way in protecting natural darkness as a precious resource and create a model for dark sky protection by establishing America's first Dark Sky Cooperative on the Colorado Plateau in collaboration with other federal agencies, partners, and local communities.

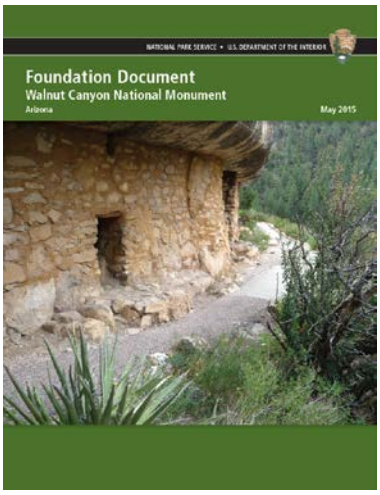
As a piece of the newly formed Colorado Plateau Dark Sky Cooperative, the Flagstaff Area National Monuments are taking lighting, conservation, and educational steps to fulfill the mission of the Call to Action #27, Starry, Starry Night. This voluntary initiative forms America's first Dark Sky Cooperative, 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. Flagstaff Area National Monuments' International Dark Sky Park designation would bring further awareness and legitimacy to the Cooperative.

"Go Green: Action 23"
Further reduce the NPS carbon footprint over 2009 levels, and widely showcase the value of renewable energy. To accomplish this, we will foster sustainability in our parks and with our partners by reducing greenhouse gas emissions by 20 percent, including on-site fossil fuel usage and emissions due to electricity consumption.

The Flagstaff Area National Monuments have embraced the Call to Action #23, Go Green, in all aspects of operations. The night sky lighting retrofits are a great example of this. With all the retrofits, the monuments will reduce lighting energy consumption by 90% - contributing greatly to the monuments' reduction of greenhouse gas emissions.

Flagstaff Area National Monuments Management Actions

The Foundation Document for each monument functions as a "formal statement of its core mission that will provide basic guidance for all planning and management decisions."



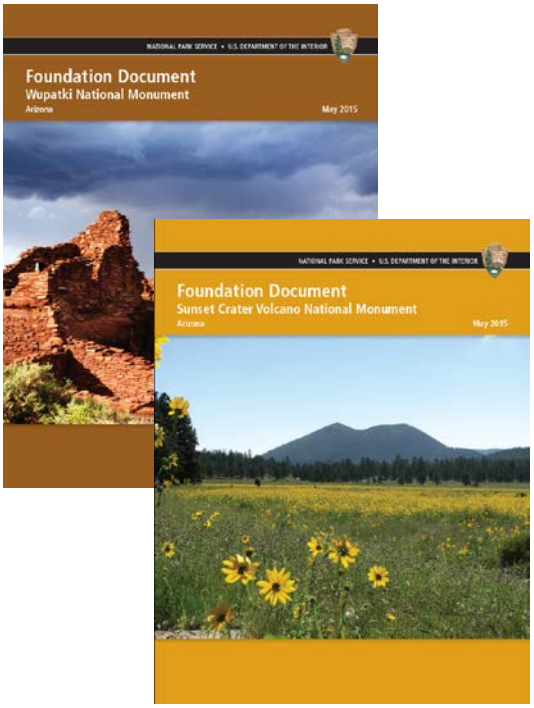
Walnut Canyon Foundation Document (May 2015)

Threats are identified as: "neighboring land uses can contribute to increases in artificial light and noise which can negatively affect the setting at the park unit" and "any increase in nearby artificial light could impact the night time environment and night sky resources."

Opportunities are identified as: "developing partnerships with local night sky organizations", "retrofit, replace, and maintain park lighting infrastructure to use night sky friendly lighting", and "participate in the Colorado Plateau Dark Sky Cooperative 'Starry, Starry Night,' a voluntary effort to promote the preservation, enjoyment, and tourism potential for star gazing in the vast region."

Wupatki Foundation Document (May 2015)

In Fundamental Resource or Value: Natural Setting/Wilderness, it is recognized that "The largely undeveloped terrain conveys wilderness values through a sense of solitude, dark night skies, and natural quiet."



One of the identified Interpretive Theme - Scenic Views and Soundcapes, emphases "Today Wupatki provides an increasingly rare opportunity to glimpse past cultures' experiences – viewing vast undeveloped landscapes and clear, dark nights skies, the feelings of solitude and natural quiet. These circumstances invite contemplation, inspiration, and renewal. Today's actions determine whether these experiences will exist for future generations."

The Wupatki Foundation Document echoes the same opportunities identified in the Walnut Canyon document.

Sunset Crater Volcano Foundation Document (May 2015)

In Fundamental Resource or Value: Landscape/Scenery, it is recognized that "Sunset Crater Volcano National Monument offers spectacular views of undisturbed volcanic landscapes, cinder dunes, and lava flows. These views occur within an environment of clean air and pristine night skies."

Threats are identified as: "Residential and other development within Flagstaff may impact night sky character and acoustic environment."

The Sunset Crater Volcano Foundation Document also echoes the same opportunities identified in the Walnut Canyon and Wupatki documents.

Flagstaff Area National Monuments Lighting Management Plan

1.1 Introduction

In conformance with NPS Management Policy 4.10— Natural Lightscapes, the installation and use of artificial outdoor lighting should be used only when and where dictated by safety, and should not be driven by convenience. Mitigation should be employed to the maximum practical extent. These guidelines direct park management to design park lighting to mitigate light pollution and to preserve natural darkness as much as possible.

The Flagstaff Area National Monuments (FLAG) includes Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments. Visitors experience a meandering limestone canyon with wooded rims and cliff dwellings, stark black volcanic landscapes, and the prominent pueblos atop red sandstone. These experiences are solidified further by access to night-time views which allow for quiet contemplation of not just the vastness of the Southern Colorado Plateau landscape, but the vastness of our Universe. This night sky is a diminishing resource that the National Park Service seeks to preserve. The goal of this Lighting Management Plan (LMP) is to provide for the safety, security and route finding of Park visitors and staff without any significant impact on the night skies of FLAG.

Good lighting design and application requires the synthesis of several human and environmental factors— what visual tasks are to be performed, psychology of security, ocular adaptation level, fixture efficacy, lamp efficacy, fixture placement, ambient illumination level, light spectrum, and lighting controls (i.e. switches, timers, and dimmers) to name a few. Additionally there are environmental consequences of artificial outdoor lighting related to direct glare, angular distribution, atmospheric scattering, color, duration, and intensity. FLAG is surrounded by Coconino County, which has appreciably strict lighting codes. This lighting plan is no less restrictive than Coconino County's Section 27.6: General Requirements, all Zones.

The National Park Service Night Sky Team has created two documents to assist individual parks in creating an LMP. These are listed below under "Sources" along with other guiding documents that have contributed both ideas and language for this LMP. Fortunately, the primitive nature of most of FLAG, along with the small scope of facilities in the park, both extant and planned, means that the LMP for FLAG is generally simple and in line with what park staff and visitors have come to expect.

Light Pollution

A natural lightscape is one that is free of light pollution. Spilled light or wasted light are phrases that describe the misuse of outdoor lighting, especially in a natural or protected environment such as a national park. The term light pollution has commonly been used to emphasize the concept that anthropogenic 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 national parks, including:

1. The preservation of natural lightscapes (the intensity and distribution of light on the landscape at night) will maintain the nocturnal scotopic (vision under low light conditions) environment within the range of natural variability.

2. The scenery of national park areas does not just include the daytime hours. A natural starry sky

absent of anthropogenic light is a key scenic resource.

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 aboriginal cultures is present.

4. The recreational value of dark night skies is important to park visitors, allowing the experience of enjoying the night sky.

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.

1.2 Guiding Principles

Providing light for visitor and staff safety in commonly used developed areas will be achieved while protecting the natural environment from light pollution.

Outdoor lighting zones will be delineated in the Flagstaff Area National Monuments management plans (specifically this document), with each zone having varying degrees of visitor expectations for natural darkness/outdoor lighting, varying degrees of nighttime use and activity, and/or varying degrees of cultural/natural sensitivity.

Energy efficiency is a goal for all outdoor lighting, as it lessens the park's carbon footprint. An important distinction here, however, is that an energy efficient light is not necessarily a night-friendly light. Long term sustainability in the operation and maintenance of outdoor lighting solutions should be maximized. The total lifecycle cost should be weighed in a sustainability assessment.

Outdoor lighting will be sensitive to the impact upon wildlife. The addition of artificial light into a park setting alters nocturnal habitat, and the impact may reach beyond the bounds of the developed area. Parameters of direct light intensity, scattered light intensity, light color, light timing and duration are all important considerations for wildlife.

Cultural and Historic Resources will be supported, not degraded, by outdoor lighting. The use of period light fixtures represents a special challenge, as these are generally more decorative and less efficient than their modern equivalents. Successfully preserving the cultural and historical integrity may require additional expense and creative solutions.

Protecting the naturally dark surroundings of many park environments is an essential factor in outdoor lighting design. Because of the human eye's reliance on contrast for vision, a dark ambient environment often enables the use of lower illumination levels to achieve the same visual effect.

External threats to the natural lightscape within the parks will be addressed, primarily by setting a leadership example for and working with surrounding communities. NPS management policies put a positive responsibility upon superintendents to partner, to the extent possible, with these communities to protect the natural environment of parks. Part of this effort is to provide examples of outdoor lighting Best Practices for the public. This requires that outdoor lighting in parks be held to a high standard, that the existing lights incorporate these principles, and that park facility lighting is interpreted to visitors and the surrounding community.

1.3 Lighting Guidelines

All exterior lighting in the Flagstaff Area National Monuments shall be designed to eliminate light trespass, minimize glare, and use an intensity, color, and duration that will preserve the natural darkness as much as possible.

NPS Management Policies direct parks to use artificial light on an "only as needed" basis and to minimize impact whenever possible. Merely shielding a light does not necessarily constitute lightscape, wildlife, or night-sky friendliness; especially if that light is unnecessary in the first place. Even when a light is necessary, the incorporation of a timer, motion sensor, or switch can greatly reduce its impact. The mitigation of outdoor lighting impacts upon the environment is best accomplished by addressing six parameters of lighting.

1) Warranting- Light only WHERE you need it

a. Lighting installations should be placed only where uses dictate.

2) Controls- Light only WHEN you need it

a. Rather than defaulting to a dusk-till-dawn operational cycle, lighting controls should be designed to minimize the amount of time the light is on while still fulfilling the need met by installing the light at that spot in the first place.

3) Shielding- Direct light DOWNWARD

a. No fixture should emit light above the horizontal. In most cases, beams of light should be restricted even further.

4) Spectrum- Select LAMPS that minimize negative impacts

a. Humans and many other animals are most sensitive to blue/white light. Most evening lighting goals can be achieved using warmer temperature lighting, which decreases the disruption to wildlife (including insects), maintains the human ability to adapt to low light conditions, and decreases sky glow.

b. The color tint of white light is measured in Kelvins (K), a scale in which warm-toned white light has smaller values (1800-3000K) and cold-toned light has larger values (5000K and higher). Between 3000 and 5000K, light is said to be "neutral" in tone. The common incandescent lamp is 2700K.

c. Traditional incandescent lighting is about 2700K, a warm toned light considered normal for residential and hospitality lighting in North America. For reasons of consistency and appearance, light sources should be 2700-3000K with a minimum Color Rendering Index of 70. Amber or yellow light sources are preferable, both to limit attraction by insects and to reduce sky glow. Light sources should be chosen for energy efficiency, long life and low maintenance. Because some locations in the park experience extremes of temperature, elevation and exposure, light sources must be suitable for all expected operating conditions. The following light sources are acceptable for outside use:

i. LED 2700K "warm" white lamps, yellow, or amber colored, 1, 3, or 7 watt. LED's superior life, energy efficiency, instant starting and low temperature performance are superior but some capabilities of the source are limited. Use with caution in hot climates. Use amber LEDs in most environmentally sensitive areas.

ii. Compact fluorescent, 9 watt, twin tube and 13 watt double twin tube or Edison base spiral 3, 7, 10, 13 or 26 watt (2700K only or yellow "bug lamps"). Because of low starting temperature and low cost components, this light source can be used for many basic outdoor lighting applications.

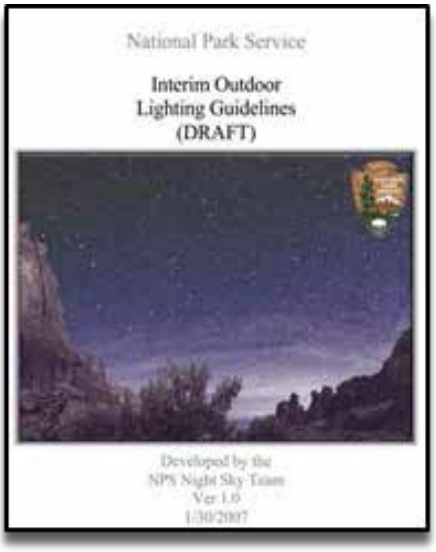
5) Intensity- Use the minimum AMOUNT of light necessary

6) Efficiency- Select the most energy EFFICACIOUS lamp and fixture

Existing Standards and Codes

A Royal Astronomical Society of Canada (RASC) Dark Sky Park is defined as an area whose night sky has little or no sky glow and minimal lighting within the DSP. As such, FLAG has created and adapted a lighting guideline outline that minimizes the lighting within the park.

From the NPS Interim Outdoor Lighting Guidelines



Best management practices for outdoor lighting will:

- Curtail and reverse the degradation of the nighttime visual environment and the night sky, including casual observation, astronomy, and air quality related values.
- Minimize glare, light trespass, obtrusive light, and artificial sky glow by limiting outdoor lighting that is misdirected, excessive, or unnecessary.
- Ensure good neighbor lighting by minimizing light trespass.
- Help minimize suspected health risks to humans from adverse exposure to light at night.
- Help protect natural ecosystems from the damaging effects of night lighting.
- Permit reasonable and rational use of outdoor lighting for nighttime safety, utility, security, and productivity.
- Help to conserve energy and resources.
- Minimize maintenance and operating costs
- Provide some flexibility for architectural and artistic lighting within the above constraints

2.1 Lighting Zones

While the Flagstaff Area National Monuments cover a large area, their amenities are limited. Each monument contains a small visitor center, residential area, and maintenance/administrative areas. Beyond these limited visitor and employee areas, the park is unlit by artificial lighting. Trailheads and parking areas remain dark, and fulfill the visitor expectation for a dark sky experience.
The park can be divided into two zones:

- **Zone One**, where minimum artificial lighting is deemed necessary for safety—such as at residential and visitor services areas. Zone one exists as a **Standard Lighting Zone** (SLZ), and contains structures that support the operation needs of the park. Lighting here exists on a level dictated by necessity only, and should be restricted temporally and spatially.

- **Zone Two** is the majority of the park, and contains no artificial lighting. This zone includes trailheads, and roads, as well as the general areas of the park. Zone two is a **Natural Darkness Zone** (NDZ), where no permanent light fixtures exist. Any lighting needs in this zone will be on an individual case, and will be addressed by temporary lighting devices such as flashlights. This zone comprises the natural and solitude values of the park, and minimizing and eliminating light trespass into this zone is paramount.

Lighting Standards

Standard Lighting Zone (SLZ)

Exterior Lighting exists solely for security and convenience. Lights shall remain on only in minimum capacity, and with the aim of safety. FLAG has altered and retrofitted much of the outdoor lighting in all the monuments. 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, 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:

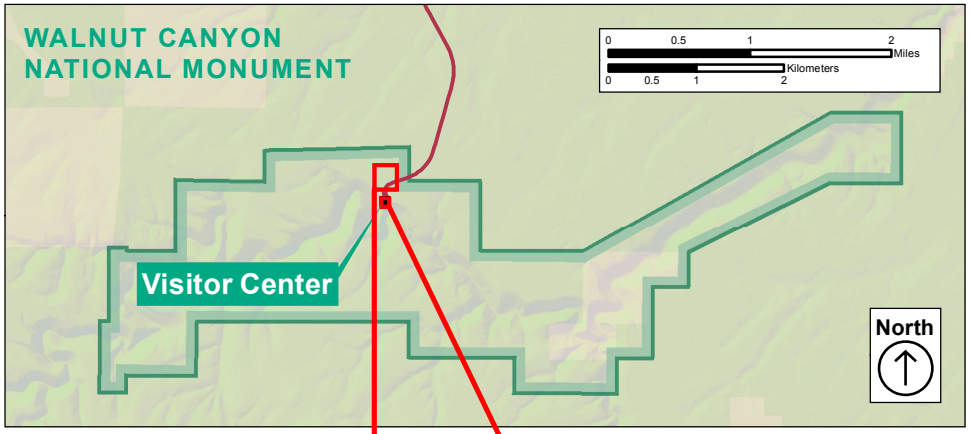
- Light fixtures should exist only where needed for specific tasks.
- Light should only exist when necessary. Lights should operate on manual switches or motion sensors/timers.
- Light should only exist in the minimum amount necessary. Individual fixtures should be limited to 600 lumens, with exceptions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

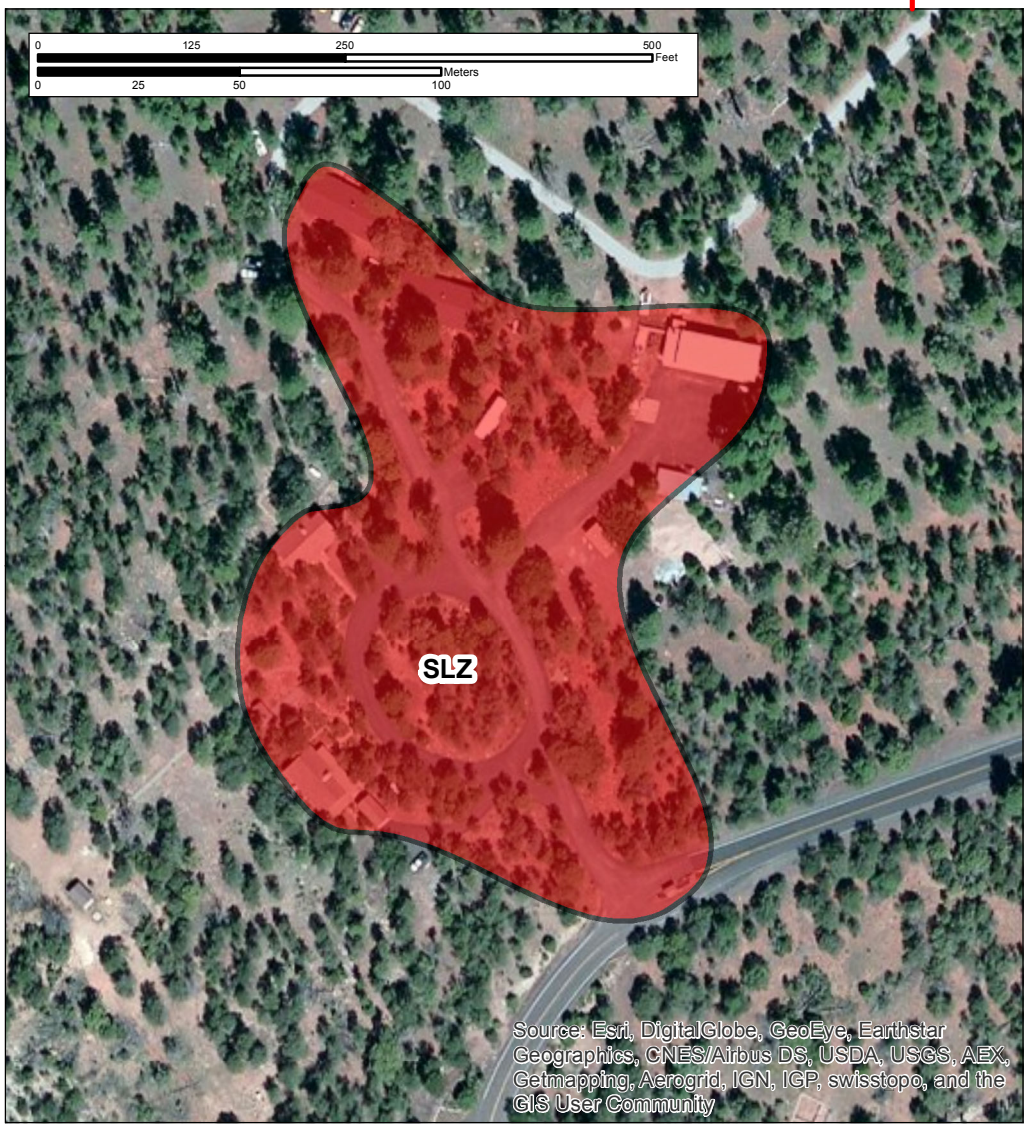
Natural Darkness Zone (NDZ)

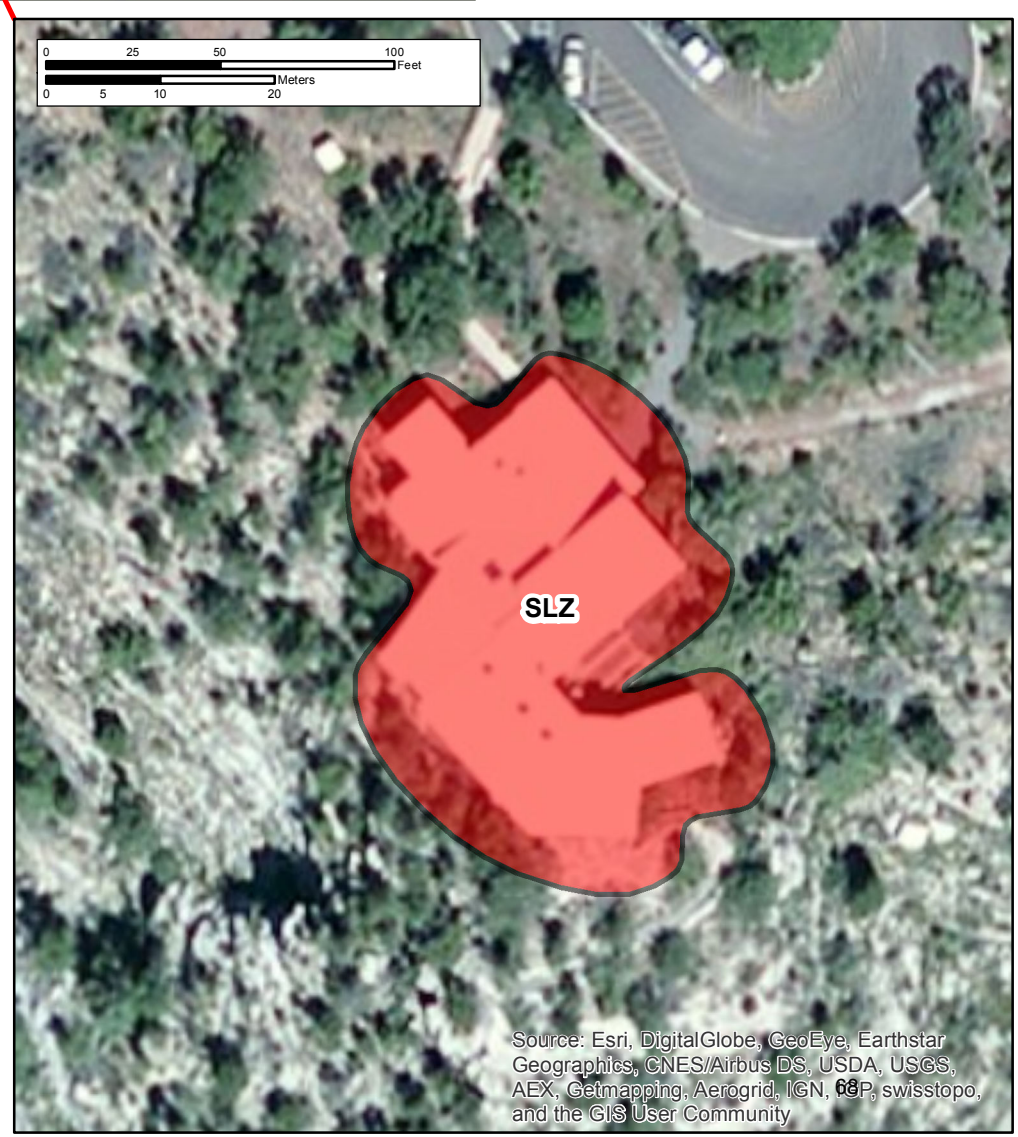
All areas outside of Zone One, the Standard Lighting Zone, fall under this zone. These areas include the entirety of Sunset Crater Volcano's legislative boundary, the 545 Road corridor through Wupatki and Sunset Crater Volcano, and the historic Ranger Cabin at Walnut Canyon. No permanent lighting exists or is allowed in this area. Light trespass from outside sources and Zone One is minimal and all attempts are made to eliminate any excess light pollution. This area makes up the large majority of the Flagstaff Area National Monuments.

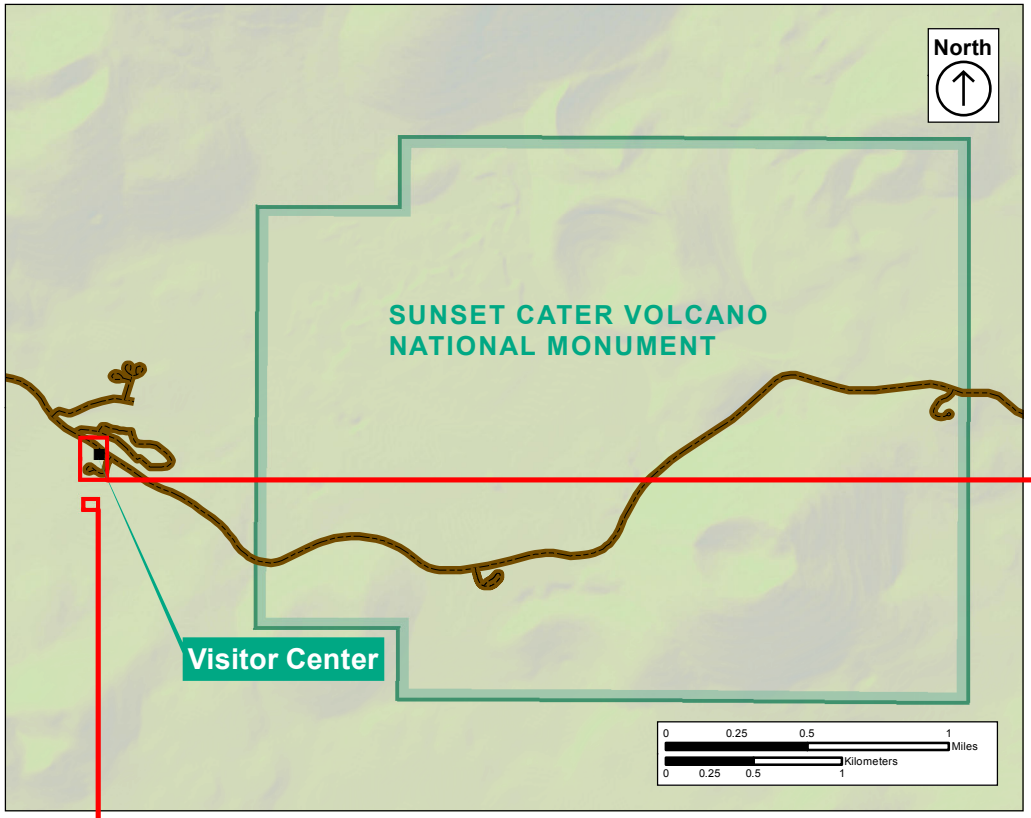
Conclusion

FLAG 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 and with NPS Management policies, which state that it is important to specify the need in each case of outdoor lighting and choose the appropriate lighting design. Artificial lighting in the park does not exist in areas where there is an expectation for darkness by the visitor and employees.


WALNUT CANYON
NATIONAL MONUMENT
0 0.5 1 2
Miles
0 0.5 1 2
Kilometers
Visitor Center
North

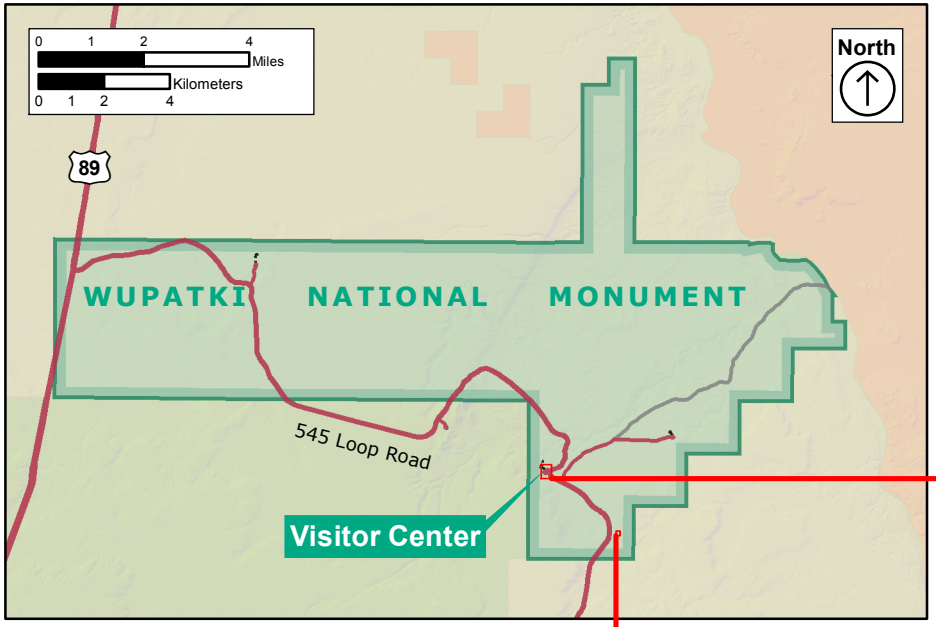

0 125 250 500
Feet
0 25 50 100
Meters
SLZ
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


0 25 50 100
Feet
0 5 10 20
Meters
SLZ
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

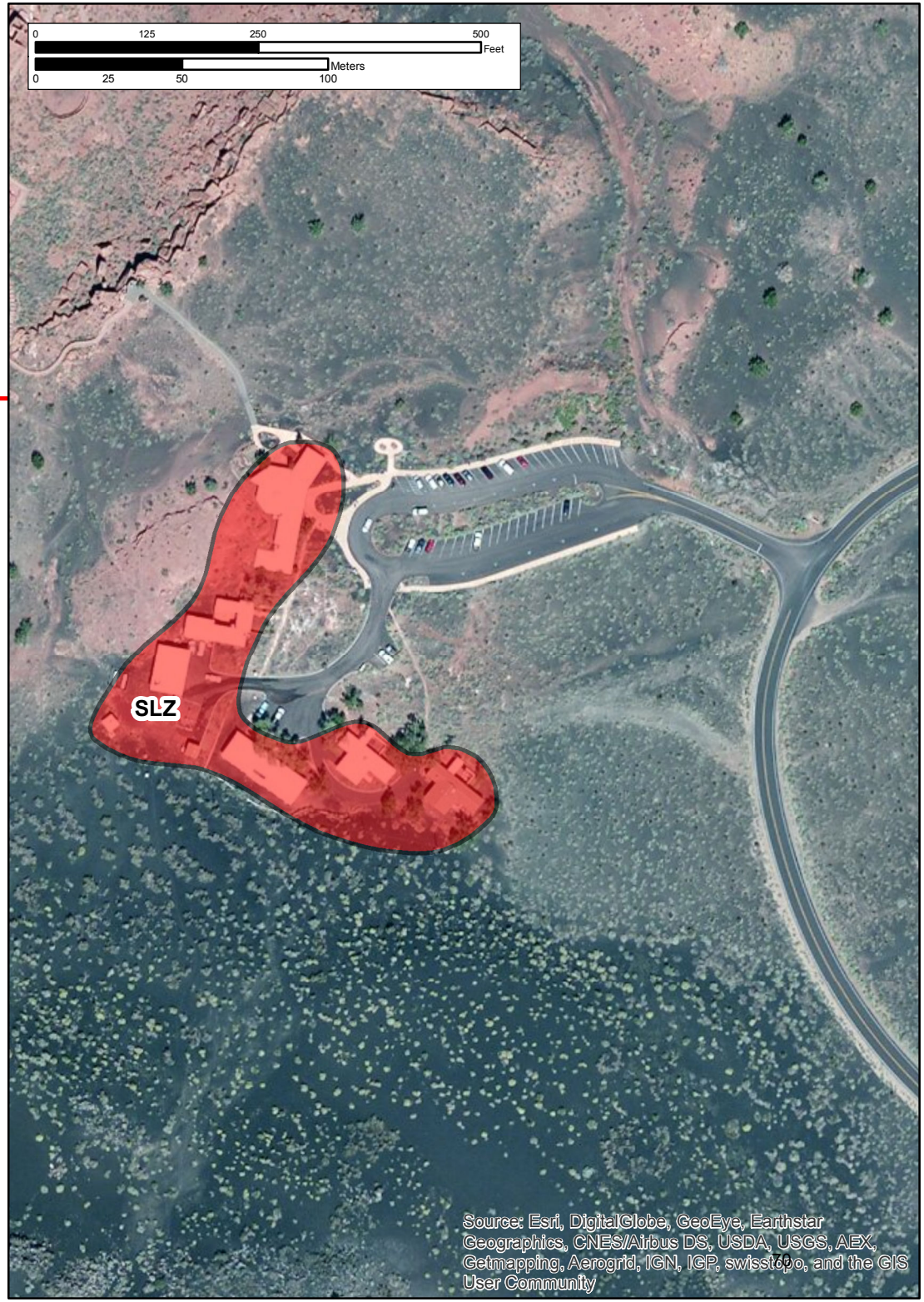

North
SUNSET CATER VOLCANO
NATIONAL MONUMENT
Visitor Center
0 0.25 0.5 1
Miles
0 0.25 0.5 1
Kilometers


0 25 50 100
Feet
0 5 10 20
Meters
SLZ
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


0 50 100 200
Feet
0 12.5 25 50
Meters
SLZ
SLZ
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


0 1 2 4
Miles
0 1 2 4
Kilometers
North
89
WUPATKI NATIONAL MONUMENT
545 Loop Road
Visitor Center


0 25 50 100
Feet
0 5 10 20
Meters
SLZ
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


0 125 250 500
Feet
0 25 50 100
Meters
SLZ
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

4 Letters of Support

Star Trails, Lomaki
Photo/Stan Honda

United States Department of the Interior
NATIONAL PARK SERVICE
WUPATKI – SUNSET CRATER VOLCANO – WALNUT CANYON
NATIONAL MONUMENTS
6400 N Highway 89
Flagstaff, Arizona 86004

N16
(FLAG)

January 19, 2016

IDA Board of Directors
International Dark-Sky Association
3225 North First Avenue
Tucson, Arizona 85719

Dear Board Members:

I am pleased to offer my support for International Dark Sky Park designation for the three Flagstaff Area National Monuments – Walnut Canyon, Sunset Crater Volcano, and Wupatki.

One of my seasonal park ranger experiences with the National Park Service (NPS) was at Wupatki National Monument in 1984. My interpretive duties that summer included a weekly trip to the US Forest Service campground at Sunset Crater Volcano to bring interested visitors to Wupatki Pueblo by school bus for an evening program. Invariably, as darkness enveloped the pueblo, visitors were astonished and delighted to see the Milky Way with such clarity. Those more familiar with constellations shared their knowledge with those who had never seen such a huge expanse of star-lit sky. Back at my government trailer in a small housing area that no longer exists, my roommate and I often sat outside in the dark, watching the constellations and moon move overhead. The night sky at Wupatki was a key part of my favorite summer as a seasonal ranger, both on and off duty.

Thirty-two years later, I am happy to be part of the National Park Service team at the Flagstaff National Monuments again as we seek official recognition of our efforts to preserve and interpret dark skies at Wupatki, Sunset Crater Volcano, and Walnut Canyon. Efforts began four years ago as the NPS Night Skies Program collected night sky brightness measurement. In 2013 park staff created a plan and strategy for replacing exterior lighting fixtures to comply with dark sky lighting best practices. For the past three years, we have worked to implement that plan, as our nomination package shows. We have also stepped up public programming, both within the monuments and at a variety of dark sky events in the Flagstaff community, to interpret the night skies and importance of preserving dark skies. We have lots of help and inspiration right here, as Flagstaff is also an IDA Dark Sky Place. Lowell Observatory and the US Naval Observatory anchor the set of agencies and organizations focused on night sky observation and public education. Coconino County and the City of Flagstaff understand the many benefits of protecting dark skies and have included us in workgroups to consider lighting code modifications.

We are fortunate to be in a region where dark skies are valued and celebrated. Our nomination has broad support as indicated by the attached letters. We particularly appreciate the nomination letter provided by our local chapter of IDA – the Flagstaff Dark Skies Coalition. You will also find letters of support from Lowell Observatory, the Flagstaff Ranger District of the Coconino National Forest, US Fish and Wildlife Service, Coconino County Board of Supervisors, City of Flagstaff Sustainability Program, the National Park Service Intermountain Regional Office (Natural Resources), and Friends of Flagstaff National Monuments.

We look forward to your consideration of our request for designation as a Dark Sky Park. The designation would be a wonderful way for us to commemorate the National Park Service Centennial during 2016!

Sincerely,

Kayci Cook Collins
Superintendent

ANN KIRKPATRICK
1ST DISTRICT, ARIZONA

AGRICULTURE COMMITTEE
SUBCOMMITTEES
COMMODITY EXCHANGES, ENERGY, AND CREDIT
CONSERVATION AND FORESTRY
GENERAL FARM COMMODITIES AND RISK MANAGEMENT

TRANSPORTATION AND INFRASTRUCTURE COMMITTEE
SUBCOMMITTEES
HIGHWAYS AND TRANSIT
WATER RESOURCES AND ENVIRONMENT
AVIATION

Congress of the United States
House of Representatives
Washington, DC 20515–0301

201 CANNON HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-3361

405 NORTH BEAVER STREET #6
FLAGSTAFF, AZ 86001

211 NORTH FLORENCE STREET #1
CASA GRANDE, AZ 85122

11555 WEST CIVIC CENTER DRIVE #104A
MARANA, AZ 85653

550 NORTH 9TH PLACE
SHOW LOW, AZ 85901

1400 EAST ASH
GLOBE, AZ 85501

P.O. BOX 1952
HIGHWAY 191
CHINLE, AZ 86503

January 27, 2016

Board of Directors
International Dark-Sky Association
3223 N. First Ave.
Tucson, AZ 85719-2103

Dear International Dark-Sky Association Board of Directors,

I would like to express my support for the Flagstaff Area National Monuments International Dark Sky Park nomination.

According to your organization, an International Dark Sky Park possesses "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," and this certainly applies to Flagstaff Area National Monuments. Walnut Canyon, Wupatki, and Sunset Crater Volcano are cared for by the National Park Service (NPS), and the NPS preserves the natural and cultural resources of the monuments in accordance with the agency's mission while also maintaining public enjoyment in ways that protect in perpetuity the special qualities of each monument. As a Flagstaff resident, I understand the value that the Flagstaff Area National Monuments provide for our community, and I believe that a Dark Sky designation would enhance the stewardship of these beautiful monuments.

Flagstaff Area National Monuments have been preparing to request Dark Sky Park designation for some time now. Over the past several years, they have created a lighting plan and replaced the exterior lighting on public facilities and park employee housing units at all three monuments. Rangers have long been holding star parties, assisted by local astronomy volunteers and the Verde Valley Astronomy Club. NPS staff also participates in night sky programs organized by others, such as the Lights Out Flagstaff dark sky event held each March. As the City of Flagstaff is also a Dark Sky Place – the first such community to be designated by your organization – it would be wonderful to spread the Dark Sky designation to the Flagstaff Area National Monuments as well.

I am proud that my congressional district, Arizona's First District, includes so many units of the National Park system, large and small, and that the NPS seeks to protect and celebrate the spectacular dark skies that thrill so many residents and visitors in this part of the state. I urge you to approve the Dark Sky Park designation for Flagstaff Area National Monuments.

Sincerely,

The Honorable Ann Kirkpatrick
U.S. Representative, Arizona District One

COCONINO COUNTY ARIZONA
BOARD OF SUPERVISORS

VIA ELECTRONIC COPY ONLY- NO HARD COPY TO FOLLOW

Board of Directors
International Dark-Sky Association
3223 North First Avenue
Tucson, Arizona 85719-2103

Dear International Dark Sky Association Board of Directors:

The Coconino County Board of Supervisors is pleased to support the Flagstaff Area National Monuments International Dark Sky Park nomination.

Coconino County is fortunate to have three units of the National Park System within a few miles of the county seat in Flagstaff, Arizona. Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments are frequently visited by county residents, as well as people from all over the country and throughout the world. Visitors experience well preserved archeological sites, rugged lava flows and cinder cones as they visit the monuments, but they also marvel at the "big sky" aspect of each, including the spectacular dark skies. The National Park Service encourages this delight through public star-viewing and other nighttime programs both at the monuments themselves and by participating in community events in and around Flagstaff, which is itself the first Dark Sky City ever designated.

We understand that the National Park Service has completed its outdoor lighting retrofit of all facilities at the three monuments to ensure that fixtures are dark sky compliant. In this way, the NPS serves as a role model, particularly to the rural county neighborhoods closest to the monuments. Flagstaff Area National Monuments are also part of the newly formed Colorado Plateau Dark Sky Cooperative, a voluntary initiative that links communities, tribes, businesses, state and 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.

Coconino County supports National Park Service efforts to seek International Dark Sky designation for Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments. Such efforts to conserve dark skies will benefit park visitors, nearby communities, and future generations.

Sincerely,

Art Babbott
District 1
Chairman, Coconino County Board of Supervisors

219 East Cherry Avenue, Flagstaff, AZ 86001-4695 | Phone: 928.679.7144 | 800.790.1990 | Fax 928.679.7171 | coconino.az.gov

1400 WEST MARS HILL ROAD FLAGSTAFF, AZ 86001
928-774-3358 FAX (928) 774-6296

VIA ELECTRONIC COPY ONLY- NO HARD COPY TO FOLLOW December 9, 2015

Board of Directors
International Dark-Sky Association
3223 North First Avenue
Tucson, Arizona 85719-2103

Dear International Dark Sky Association Board of Directors:

On behalf of Lowell Observatory in Flagstaff, AZ, I am pleased to support the Flagstaff Area National Monuments International Dark Sky Park nomination.

I have worked with representatives from the Park Service for several years in dark-sky-related matters in the area, including with the Colorado Plateau Dark-Sky Cooperative, a voluntary initiative that links communities, tribes, businesses, state and 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. I'm therefore well aware of their ongoing commitment to dark-sky preservation and their efforts at Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments to ensure the beauty of the night sky is preserved for their visitors.

Since Flagstaff and Coconino County have some of the most thorough and comprehensive dark-sky ordinances in the world, it is most appropriate that the nearby parks are commensurately recognized for their efforts. I am therefore pleased to endorse an International Dark Sky designation for Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments. Their efforts to conserve dark skies will benefit park visitors, nearby communities, and future generations alike, and will be an important component of the long-standing tradition of dark-sky preservation in northern Arizona.

Sincerely,

Jeffrey Hall

Jeffrey Hall
Director

USDA United States Department of Agriculture | Forest Service | Flagstaff Ranger District

5075 N. Hwy. 89
Flagstaff, AZ 86004
928-526-0866
FAX: 928-527-8288

File Code: 6220
Date: January 13, 2016

Board of Directors, International Dark-Sky Association
3223 North First Avenue
Tucson, Arizona 85719-2103

VIA ELECTRONIC COPY ONLY- NO HARD COPY TO FOLLOW

Dear Board of Directors:

The Flagstaff Ranger District of the Coconino National Forest is pleased to support the Flagstaff Area National Monuments International Dark Sky Park nomination.

All three Flagstaff Area National Monuments are adjacent to Coconino National Forest lands. Visitors to all of Northern Arizona's public lands enjoy the spectacular dark skies, regardless of management jurisdiction, partly because of the great emphasis the City of Flagstaff and Lowell Observatory have placed on preserving dark skies for many years now. We appreciate the commitment made by the National Park Service at Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments to preserve dark skies, both for human enjoyment and for the benefit of wildlife. These benefits are felt on both sides of the monuments' boundaries.

The Sunset Crater Volcano's visitor center, employee housing area, and maintenance shop are actually located on National Forest and are within a few hundred feet of a popular campground operated by a USFS concessionaire. The NPS has retrofitted all of the lights on the facilities such that campers are able to enjoy being able to see the night sky with minimal interference from exterior lighting. Regular public programs are done by NPS and USFS staff and astronomy groups to highlight stargazing opportunities and educate participants on the value of dark skies.

We encourage the International Dark Sky Association to approve the NPS nomination to gain Dark Sky Park designation for Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments.

Sincerely,

Michael T. Elson
District Ranger

United States Department of the Interior

U.S. Fish and Wildlife Service
Arizona Ecological Services Office
2321 West Royal Palm Road, Suite 103
Phoenix, Arizona 85021-4951
Telephone: (602) 242-0210 Fax: (602) 242-2513

In reply refer to:
AESO/SE

January 14, 2016

Board of Directors
International Dark-Sky Association
3223 North First Avenue
Tucson, Arizona 85710-2103

Dear International Dark Sky Association Board of Directors:

The U.S. Fish and Wildlife Service (FWS) is pleased to support the Flagstaff Area National Monuments International Dark Sky Park nomination. The FWS has partnered with the three National Park Service units near Flagstaff, Arizona, Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments, on many projects and activities. In addition to managing their valuable archaeological and cultural resources, the Monuments also emphasize the preservation and protection of listed species and the maintenance of the long-term integrity of natural systems and processes within the monuments. The National Park Service encourages night-time viewing of the spectacular dark skies through public star-viewing and other nighttime programs both at the monuments themselves and by participating in community events in and around Flagstaff, which is itself the first Dark Sky City ever designated.

We understand that the National Park Service has completed its outdoor lighting retrofit of all facilities at the three monuments to ensure that fixtures are dark sky compliant. In this way, the NPS serves as a role model, particularly to the rural neighborhoods closest to the monuments. Flagstaff Area National Monuments are also part of the newly formed Colorado Plateau Dark Sky Cooperative, a voluntary initiative that links communities, tribes, businesses, state and Federal agencies, and citizens in a collaborative effort to celebrate the view of the cosmos; minimize the impact of outdoor lighting on scientific opportunities, night sky viewing, and nature; and ultimately restore natural darkness to the area.

As the primary agency responsible for management of federally-listed species and migratory birds, FWS faces the challenge of meeting recovery and conservation needs for these species in a rapidly growing area. Providing the designation of International Dark Sky Park to these Monuments would provide protection to native species, including the Mexican spotted owl, a species primarily active at night and a resident of Walnut Canyon National Monument.

We support National Park Service efforts to seek International Dark Sky designation for Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments. Such efforts to conserve dark skies will benefit listed species and other native wildlife, park visitors, nearby communities,

and future generations. If you would like further information, please contact Brenda Smith at (928) 556-2157 or Shaula Hedwall at (928) 556-2118.

Sincerely,

Brenda N Smith

for Steven L. Spangle
Field Supervisor

cc: Superintendent, Flagstaff National Monuments, Flagstaff, AZ

W:\Brenda Smith\Flagstaff Monument Dark Skies Support.docx cgg

United States Department of the Interior

NATIONAL PARK SERVICE
INTERMOUNTAIN REGION
12795 West Alameda Parkway
P.O. Box 25287
Denver, Colorado 80225-0287

IN REPLY REFER TO:
IMRO-RSS-NR (1242)

JAN 13 2016

Board of Directors
International Dark-Sky Association
3223 North First Avenue
Tucson, Arizona 85719-2103

Dear International Dark Sky Association Board of Directors:

The National Park Service (NPS) Intermountain Region is pleased to support the Flagstaff Area National Monuments International Dark Sky Park nomination. The three monuments, Walnut Canyon, Sunset Crater Volcano, and Wupatki, are located in one of the most night sky friendly regions in the continental U.S. and offer an exceptional, unfettered view of the dark night skies over the Colorado Plateau. The dark skies of the Flagstaff area have immense value to astronomical viewing, cultural resources, and wildlife conservation in the region.

Monument staff completed the required lighting plan and the fixture retrofits at all monument facilities to become dark sky compliant with regard to exterior lighting. All fixtures have 100% shielding and 94% amber narrowband LED bulbs. As most of the monuments' buildings are historic structures and exterior fixtures contribute to the historic aesthetic, the NPS has maintained those fixtures but disabled them permanently. An additional benefit of the retrofit is the reduction of energy consumption by 90% for exterior lighting at the monuments.

NPS staff has also stepped up public programming related to dark skies. For the last several years the monuments have partnered with city of Flagstaff, the Verde Valley Astronomy Club, Lowell Observatory, the Coconino National Forest, and local astronomy volunteers to host star parties at the monuments, provide constellation talks in City Parks, deliver evening programs in Forest Service Campgrounds, and participate in the City's Festival of Science. In addition, Flagstaff Area National Monuments International Dark Sky Park designation would assist in the conservation of dark night skies in the City of Flagstaff, the first International Dark Sky City, and in the Flagstaff area of Coconino County.

As a piece of the newly formed Colorado Plateau Dark Sky Cooperative, the Flagstaff Area National Monuments are taking lighting, conservation, and educational steps to 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. Flagstaff Area National Monuments International Dark Sky Park designation would bring further awareness and legitimacy to the Cooperative.

The Intermountain Region's Natural Resources Division is pleased to continue to support expansion of the network of Dark Sky Places worldwide. We hope that you will decide in favor of a Dark Sky Park designation for Flagstaff Area National Monuments.

Sincerely,

Patrick Malone
Assistant Regional Director, Natural Resources Division

cc: Kayci Cook Collins, Superintendent, Flagstaff Area National Monuments
Laura Joss, Deputy Regional Director, Intermountain Region
David Vana-Miller, Resource Stewardship Program Manager, Natural Resources Division
Randy Stanley, Natural Sounds and Night Skies Coordinator, Natural Resources Division
Nathan Ament, Colorado Plateau Dark Skies Cooperative Coordinator, Natural Resources Division

Colorado Plateau Dark Sky Cooperative

2282 S. West Resource Blvd
Moab, UT 84532

January 19, 2016

VIA ELECTRONIC COPY ONLY- NO HARD COPY TO FOLLOW

Board of Directors
International Dark-Sky Association
3223 North First Avenue
Tucson, Arizona 85719-2103

Dear IDA Board of Directors:

The Colorado Plateau Dark Sky Cooperative is pleased to support the Flagstaff Area National Monuments (FLAG) International Dark Sky Park nomination. The Monuments are located in one of the most remote 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 FLAG have immense value to astronomical viewing, cultural resources, and wildlife conservation in the region. For the last several years, FLAG has partnered with the Verde Valley Astronomy Club, Lowell Observatory, and Coconino County to host numerous astronomy events and star parties that are free to the public. In addition, FLAG International Dark Sky Park designation would assist in the conservation of dark night skies in neighboring Grand Canyon National Park, Coconino National Forest, Flagstaff, Sedona, Oak Creek, and the Navajo Nation.

As an essential piece of the newly formed Colorado Plateau Dark Sky Cooperative, FLAG is taking lighting, conservation, and educational steps to 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. FLAG International Dark Sky Park designation would bring further awareness and legitimacy to the Cooperative.

We fully support the efforts of the Flagstaff Are National Monuments as they seek designation of the FLAG International Dark Sky Park. Such efforts to conserve dark skies will benefit park visitors, nearby communities, and future generations. Should you have any questions, please contact Nate Ament at 435-719-2349.

Sincerely,

Nate Ament

Colorado Plateau Dark Sky Cooperative Coordinator

References

Guidelines for Outdoor Lighting in RASC-Dark-sky Preserves and IDA Dark Sky Places (RASC-IDA GOL)

Guidance for Outdoor Lighting Death Valley National Park (DVNP)

Canyonlands National Park Outdoor Lighting Management Plan

Interim Outdoor Lighting Guidelines (DRAFT). (2007, January 30). Retrieved December 7, 2014, from http://www.nps.gov/nabr/naturescience/upload/NPSInterimOutdoorLightingGuidelinesDraft.pdf

Longcore, T., & Rich, C. (2004). Ecological Light Pollution. *Frontiers in Ecology and the Environment*, 2(4), 191-191.

Light Pollution Atlas 2006 by David Lorenz. ClearDarkSky.com

Hand, Jenny L., et al. (2011) Spatial and Seasonal Patterns and Temporal Variability of Haze and its Constituents in the United States: Report V.

Sunset Crater Volcano National Monument Foundation Document 2015

Walnut Canyon National Monument Foundation Document 2015

Walnut Canyon National Monument General Management Plan 2007

Wupatki National Monument Foundation Document 2015

Previous page photo: Big Dipper Wupatki Pueblo, Photo/Stan Honda

Contributors

Kyle Ackerman, Park Guide, Flagstaff Area NM
Nathan Ament, Colorado Plateau Dark Sky Cooperative Coordinator
Kayci Cook-Collins, Superintendent, Flagstaff Area NM
Jay Dennis, Electrician, Flagstaff Area NM
Stan Honda, Artist-in-Residence, Wuptaki NM
Mike Jones, GIS Specialist, Flagstaff Area NM
Chris Luginbuhl, Flagstaff Dark Skies Coalition
Robert Wallace, Park Ranger, Flagstaff Area NM
Caleb Waters, Maintenance Mechanic Supervisor, Flagstaff Area NM
Jeremy White, Physical Scientist, NPS Night Skies Team