

National Park Service  
U.S. Department of the Interior  
Natural Resources Stewardship and Science



# Protecting Night Sky Resources In Our National Parks and Beyond

Rocky Mountain National Park Centennial Science Behind the Scenery  
July 16, 2015

EXPERIENCE YOUR AMERICA

National Park Service  
U.S. Department of the Interior  
Natural Resources Stewardship and Science

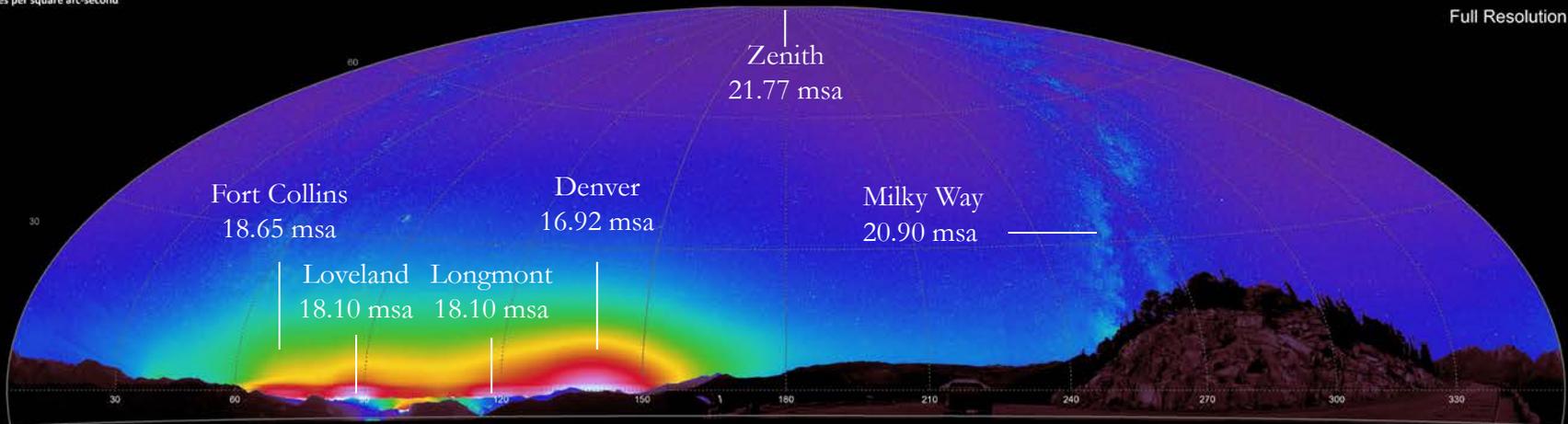
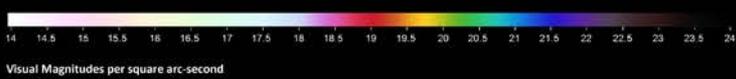


Natural Sounds and Night Skies Division

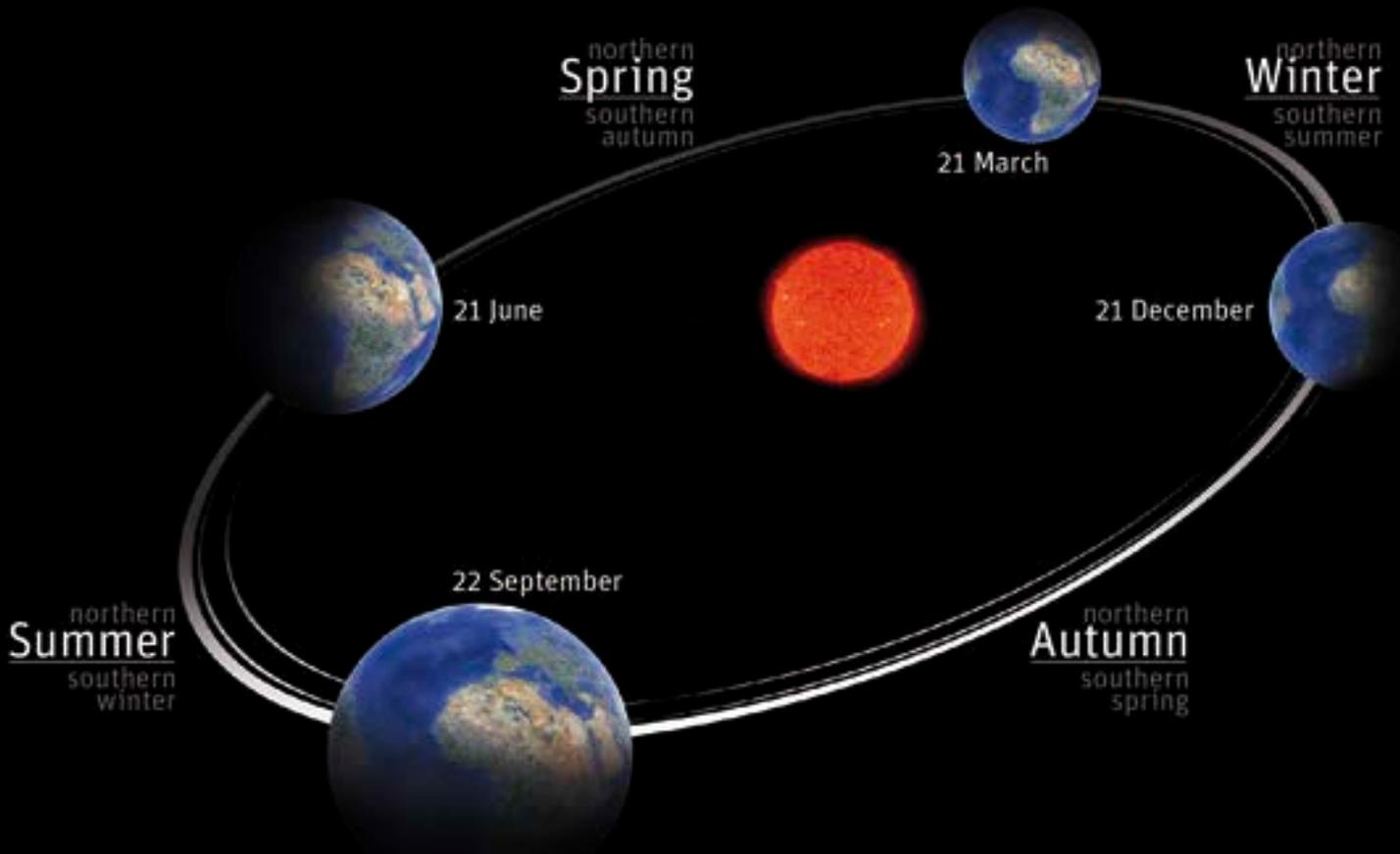
# Science Behind the Night Sky Scenery

Rocky Mountain National Park Rainbow Curve September 24, 2008 23.1 hours LMT

Full Resolution Mosaic



# Natural Rhythms of Light and Dark





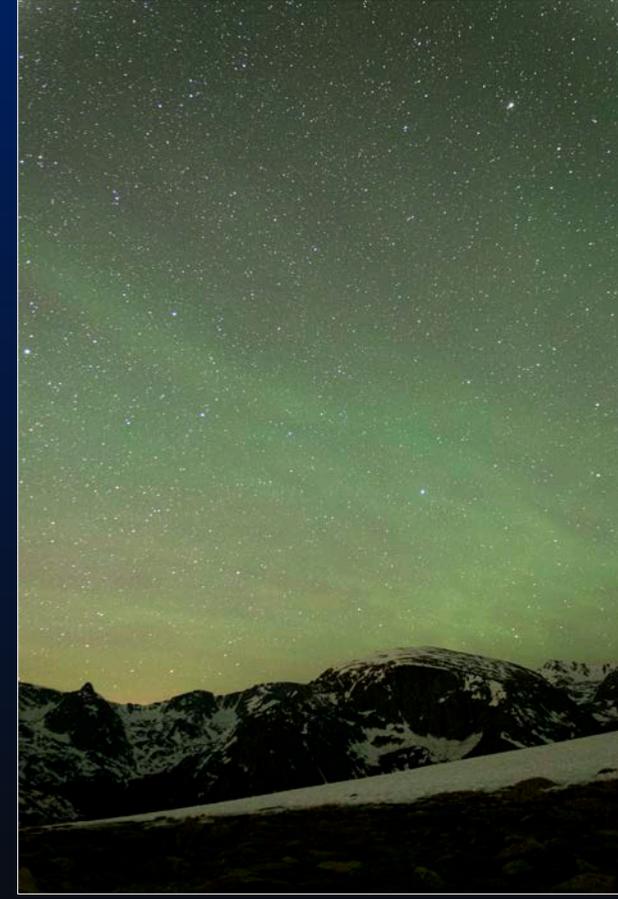
# The Natural Photic Environment



Starlight and Galactic Light



Zodiacal Light



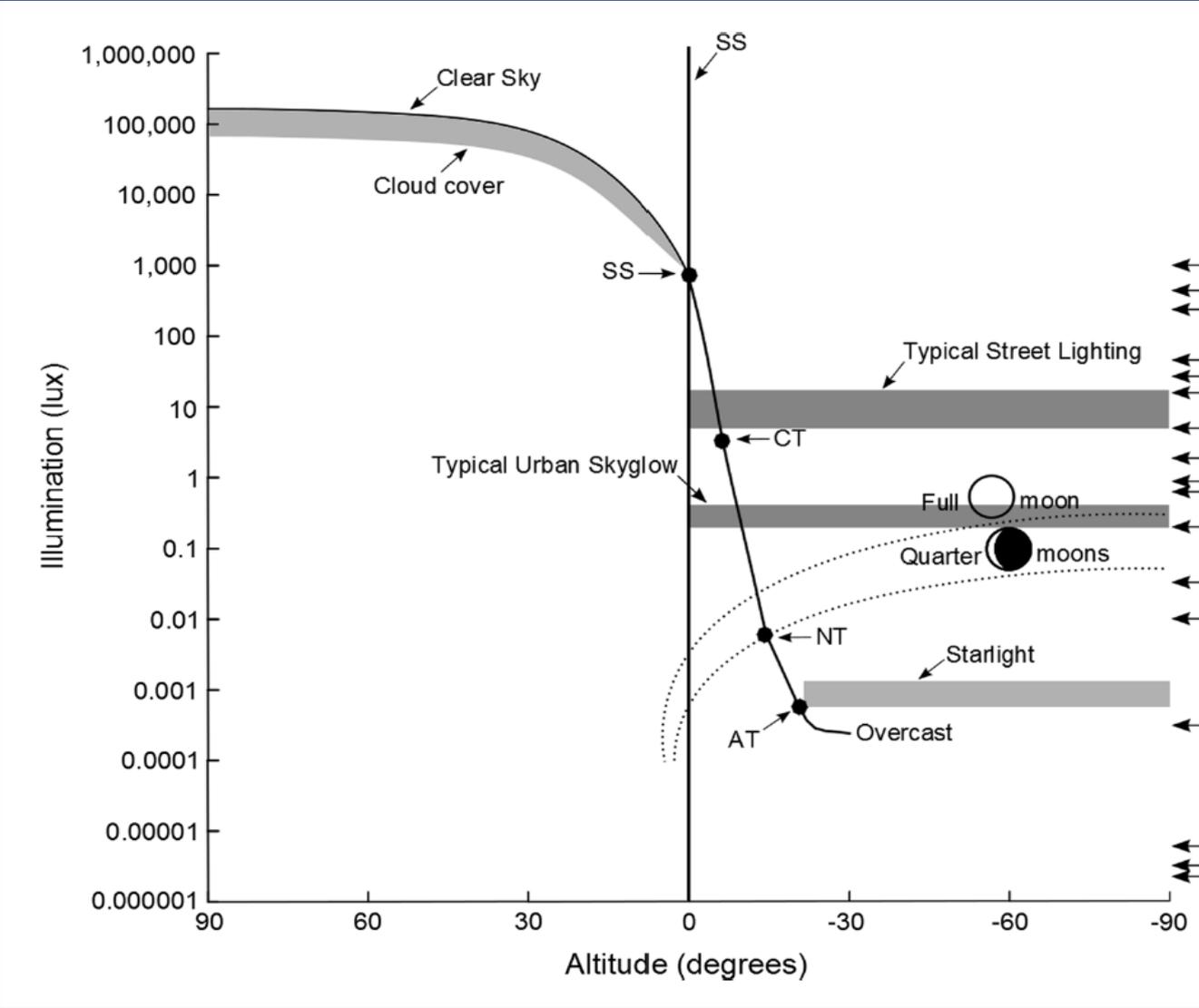
Aurora

# The Natural Photic Environment



*Fawn Wood Photography 2015 ©*

Aurora Borealis



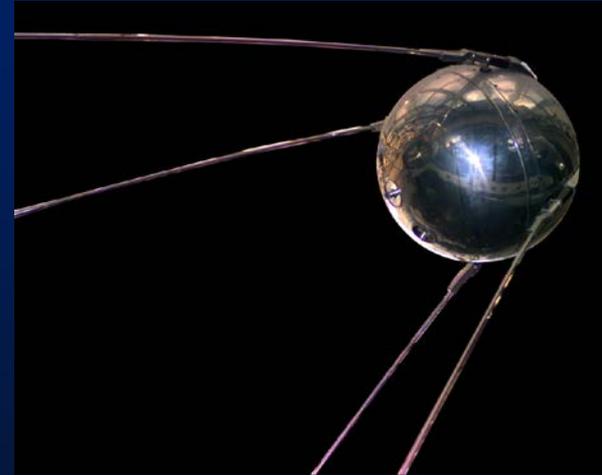
# A Bright Idea



# Changes to the Photic Environment

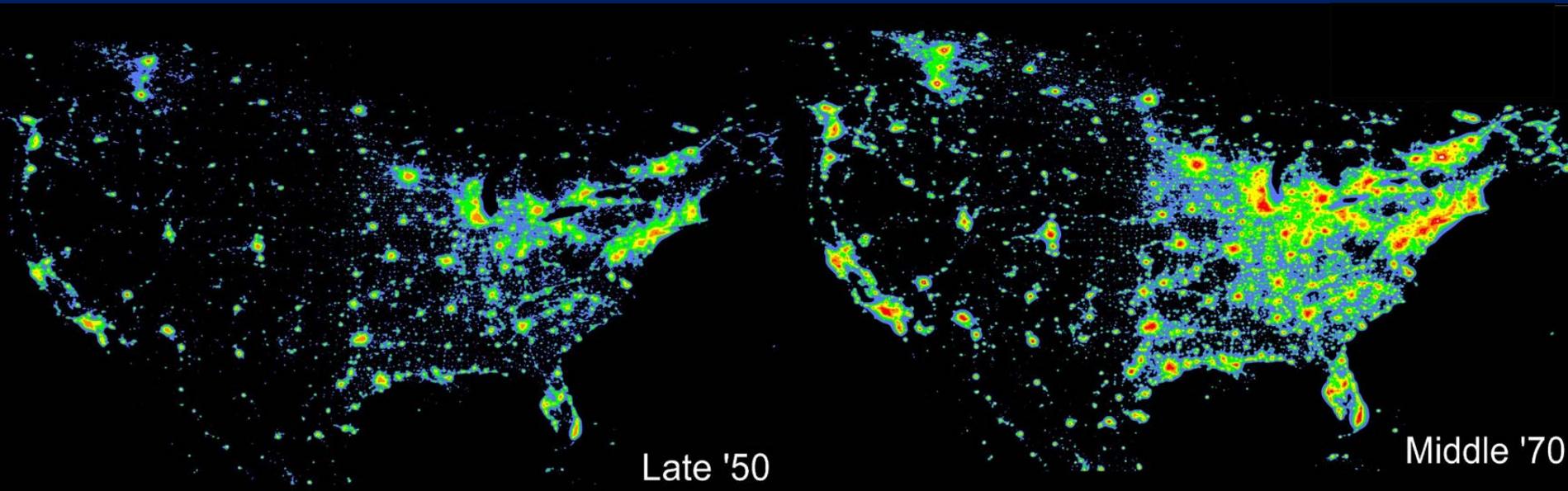


# Artificial Night Sky Brightness due to Light Pollution. *Cinzano, Falchi, and Elvidge 2001*

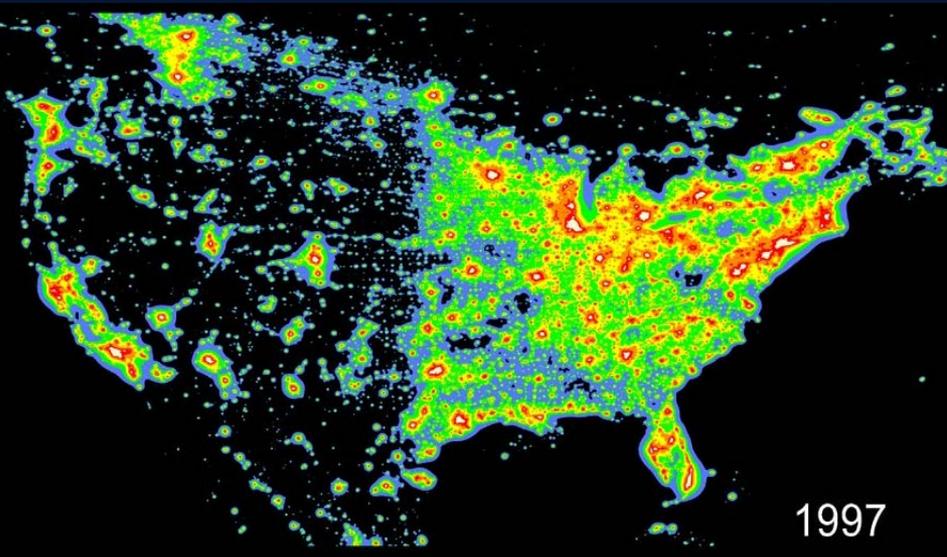
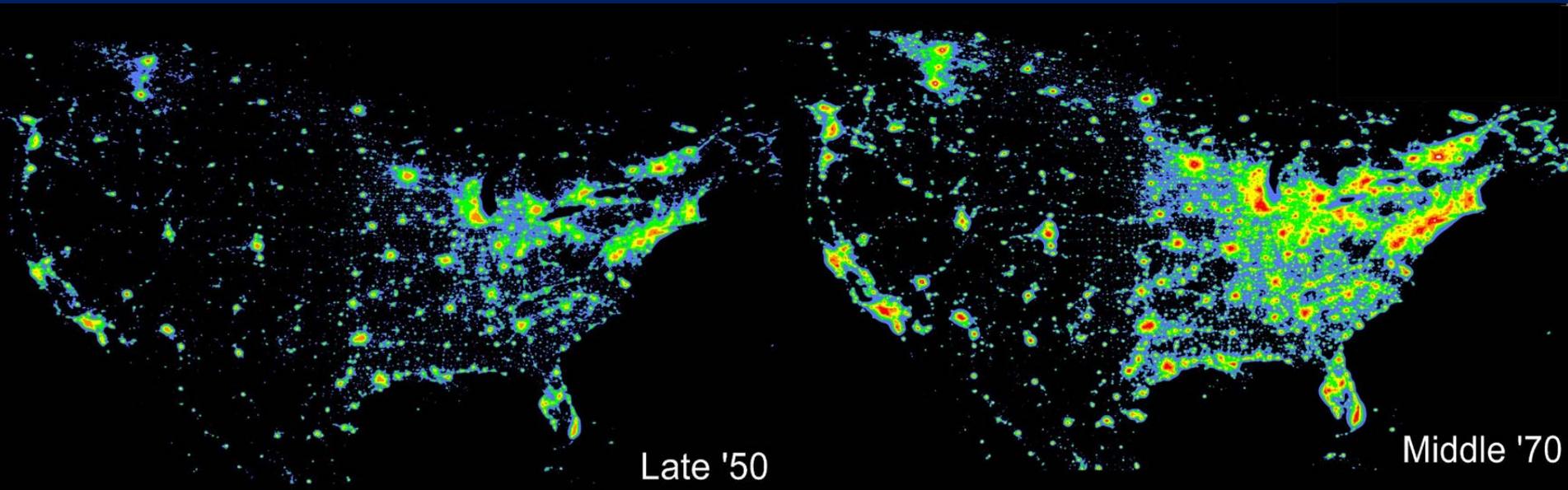


On Friday, October 4, 1957, the Soviets had orbited the world's first artificial satellite. Anyone who doubted its existence could walk into the backyard just after sunset and see it.  
—Mike Gray, "Angle of Attack"

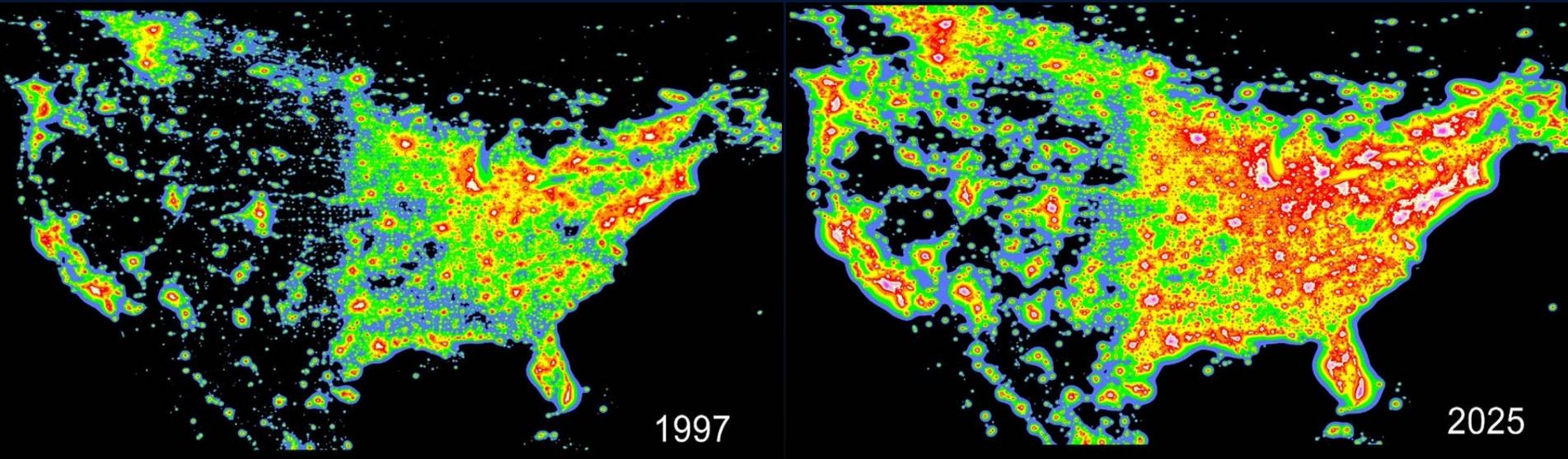
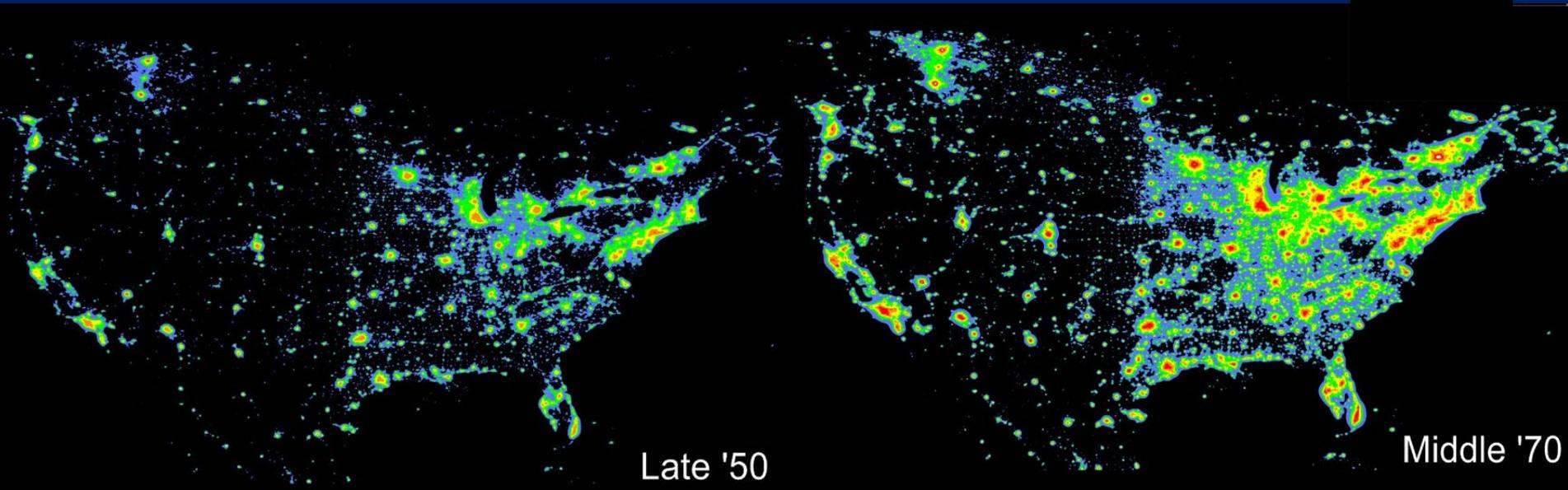
Artificial Night Sky Brightness due to Light Pollution.  
*Cinzano, Falchi, and Elvidge 2001*



Artificial Night Sky Brightness due to Light Pollution.  
*Cinzano, Falchi, and Elvidge 2001*



# Artificial Night Sky Brightness due to Light Pollution. *Cinzano, Falchi, and Elvidge 2001*





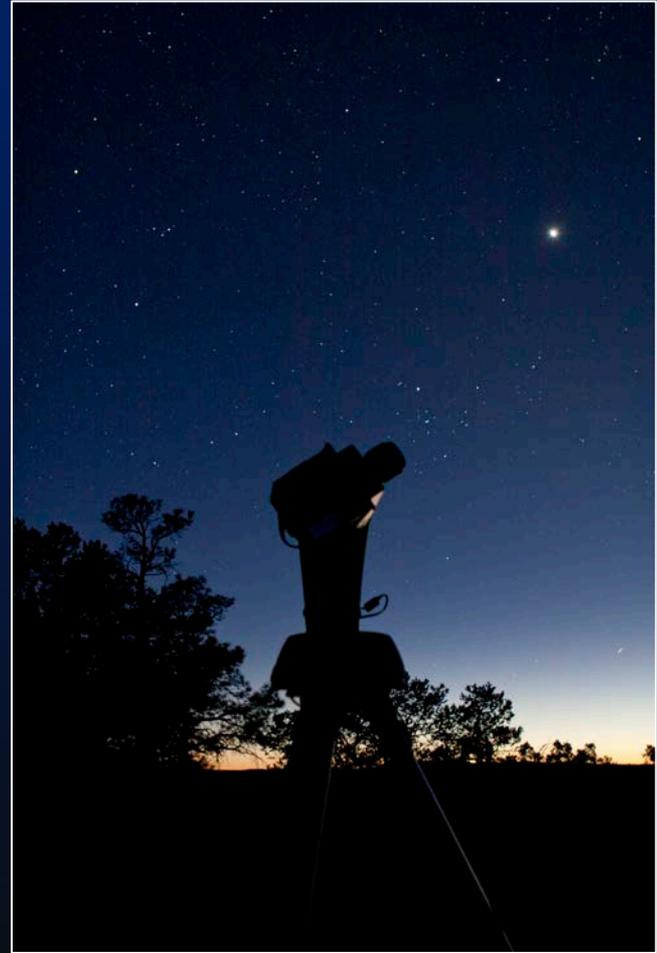
“...conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will *leave them unimpaired* for the enjoyment of future generations.”

NPS Organic Act of 1916

“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.”

NPS Management Policies 2006

# NPS Night Skies Monitoring System



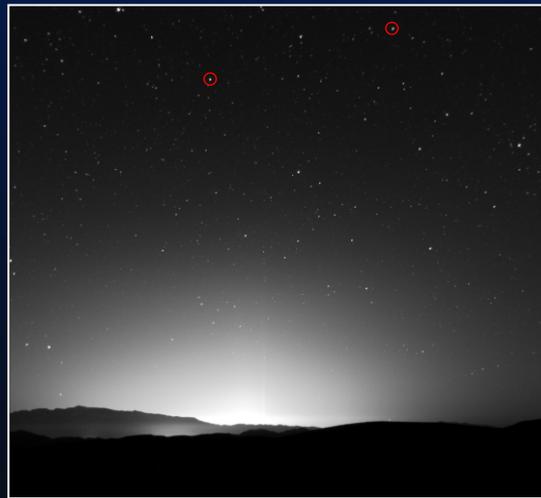
# CALIBRATED LUMINANCE AND ILLUMINANCE DATA ON ONE IMAGE

A single wide-field CCD image of the night sky with an appropriate lens/filter/detector combination can be calibrated on known standard stars, producing an array of calibrated photometric data and giving a high resolution description of sky brightness.

16 bit monochrome image



Photometry of standard stars provides calibration



Calibration applied to each pixel gives brightness measurement (luminance)



# All-sky Mosaic

Natural and Artificial Sources



# Measuring the nocturnal photic environment

## Luminance and Illuminance



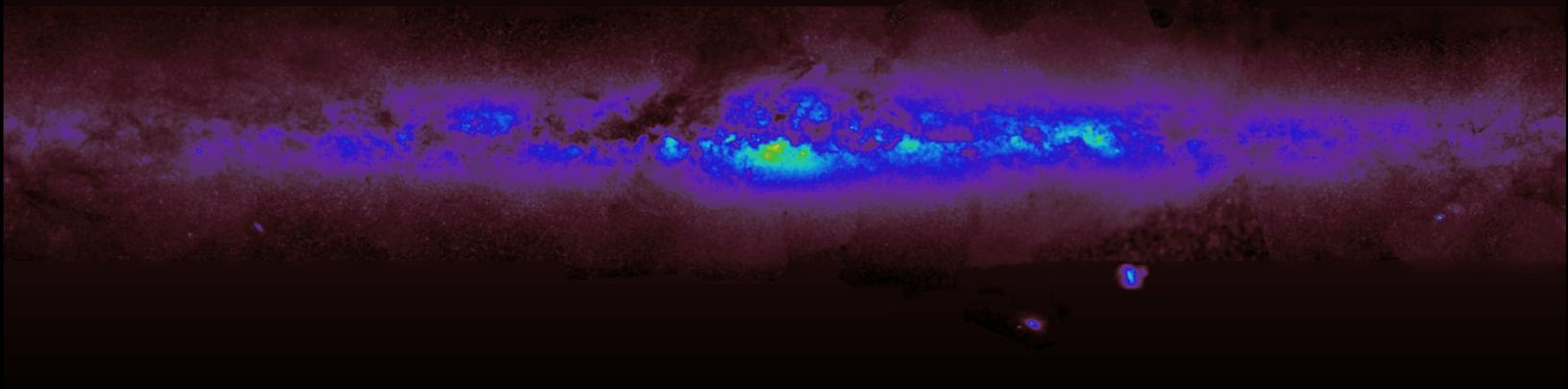
Illuminance  
from the Whole  
Sky

Horizontal  
0.8 mlux

Vertical  
0.3-0.7 mlux

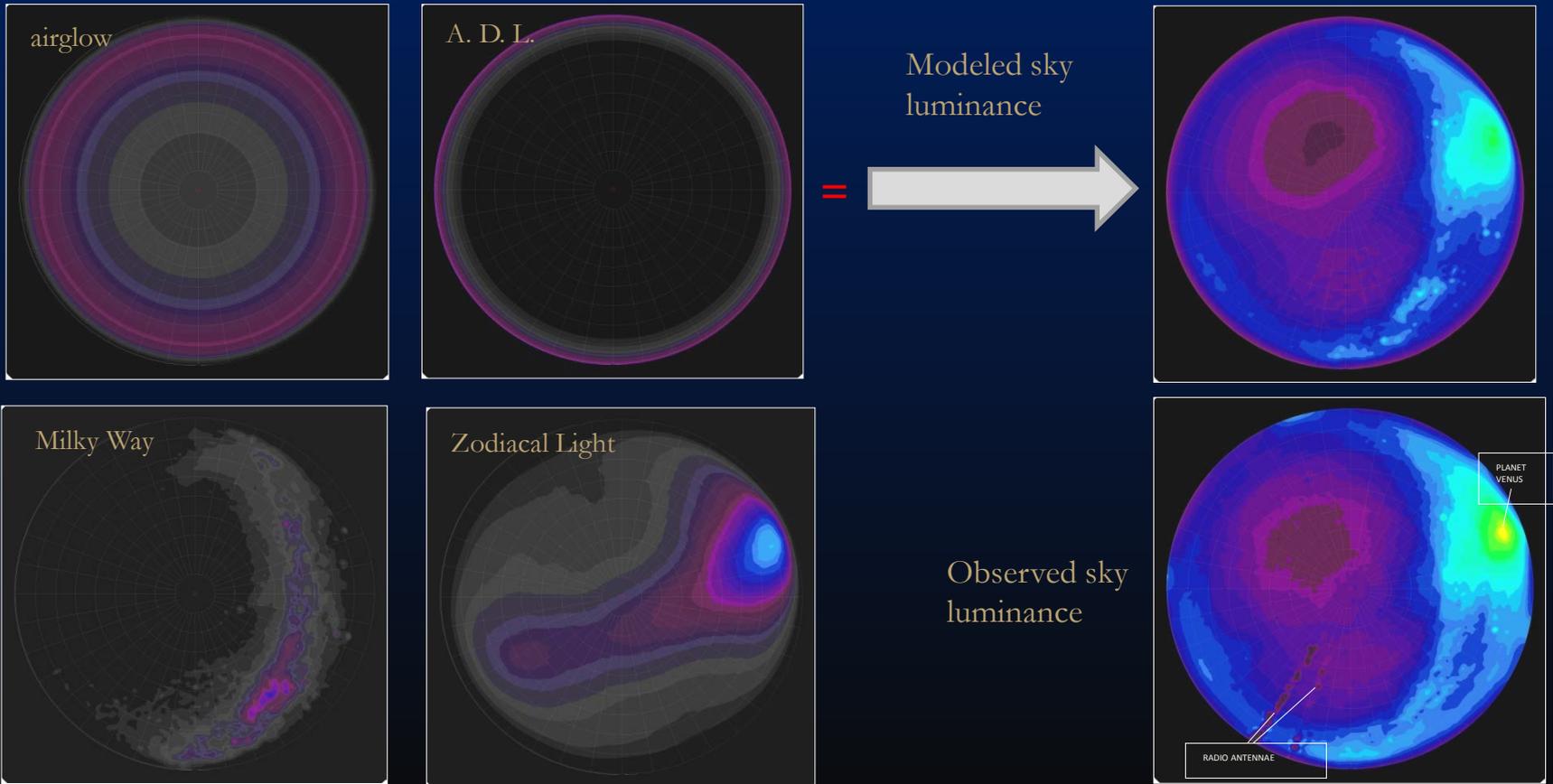
All-sky  
1.6 mlux

# NPS Milky Way Model



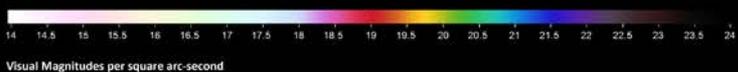
# The Natural Sky Brightness Model

Models of the Airglow, Atmospheric Diffuse Light, Milky Way, and Zodiacal light have been developed. The result is the basis of our “natural sky background brightness” for a particular data set, which is subtracted from the observed sky luminance to yield anthropogenic sky luminance.



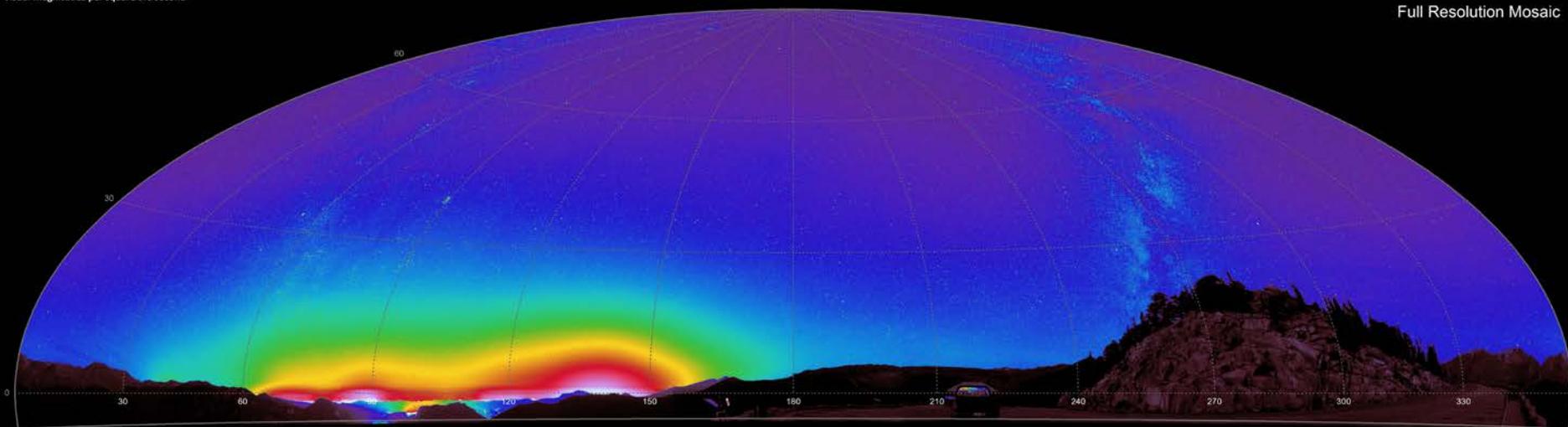
# All-sky Mosaic

Natural and Artificial Sources



Rocky Mountain National Park Rainbow Curve September 24, 2008 23.5 hours LMT

Full Resolution Mosaic



U.S. National Park Service  
Night Skies Program

Data collected by: C Moore  
Data processed by: J White

Hammer-Aitoff Equal Area Projection

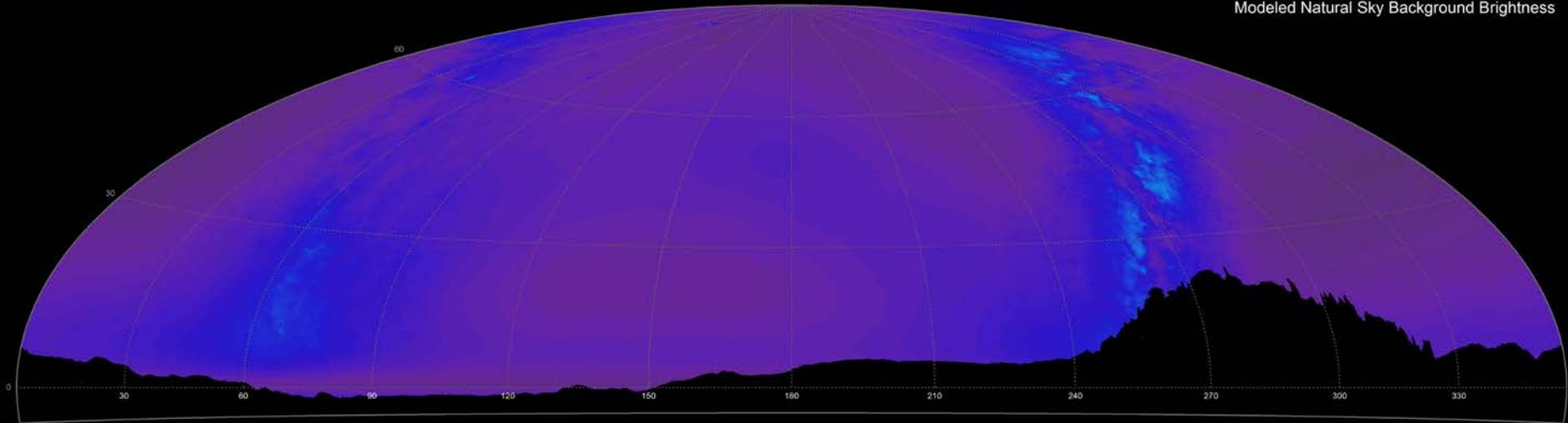
# Natural Sky Model

Natural Sources Only



Rocky Mountain National Park Rainbow Curve September 24, 2008 23.5 hours LMT

Modeled Natural Sky Background Brightness



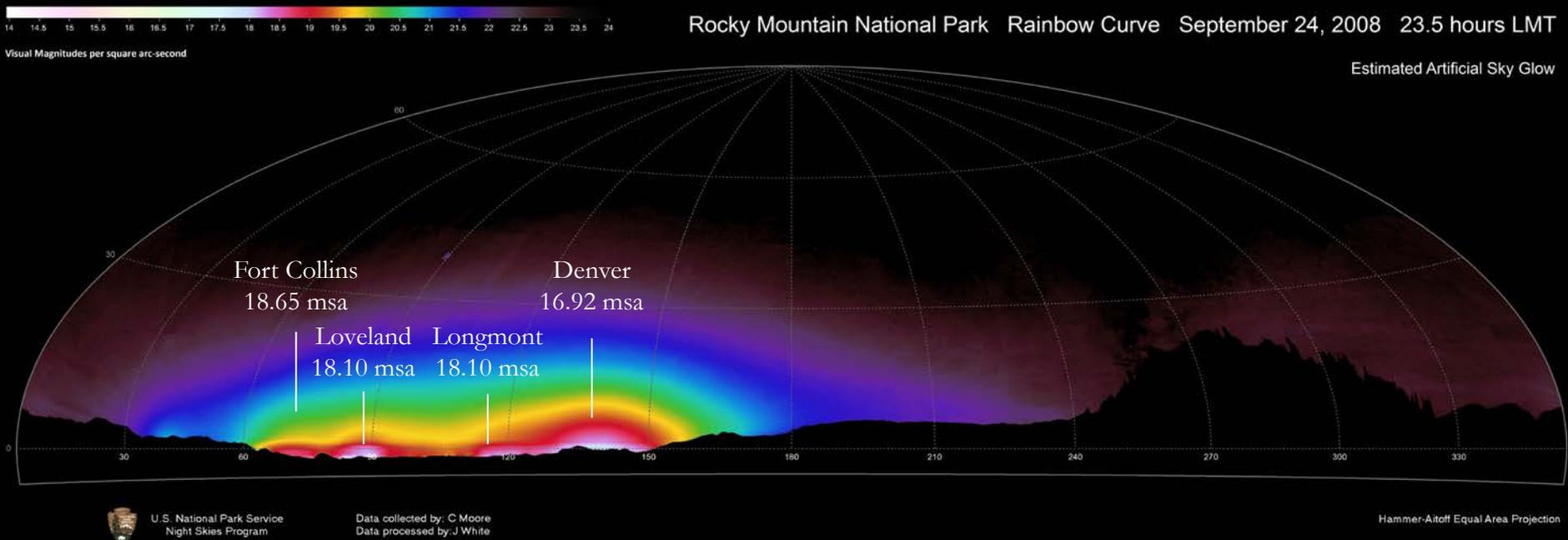
U.S. National Park Service  
Night Skies Program

Data collected by: C Moore  
Data processed by: J White

Hammer-Aitoff Equal Area Projection

# Anthropogenic Mosaic

Artificial Sources Only



ALR = 0.53

# Photometric Indicators

Indicator	Observed		Estimated Artificial		Light Pollution Ratio (Artificial/Natural)
Sky Luminance Measures					
	mag/ arcsec <sup>2</sup>	μcd/ m <sup>2</sup>	mag/ arcsec <sup>2</sup>	μcd/ m <sup>2</sup>	
Zenith	20.98	441	21.36	305	1.78
Mean all-sky	19.72	1,406	19.95	1,118	4.50
Brightest	16.62	24,155	16.63	23,957	140.10
Darkest	20.84	492	21.42	290	1.69
Median	20.18	904	20.61	609	2.44
Illuminance Measures					
	mags	milli-lux	mags	milli-lux	
Horizontal	-7.55	2.65	-7.13	1.80	2.25
Max Vertical	-8.11	4.45	-7.72	3.11	7.78



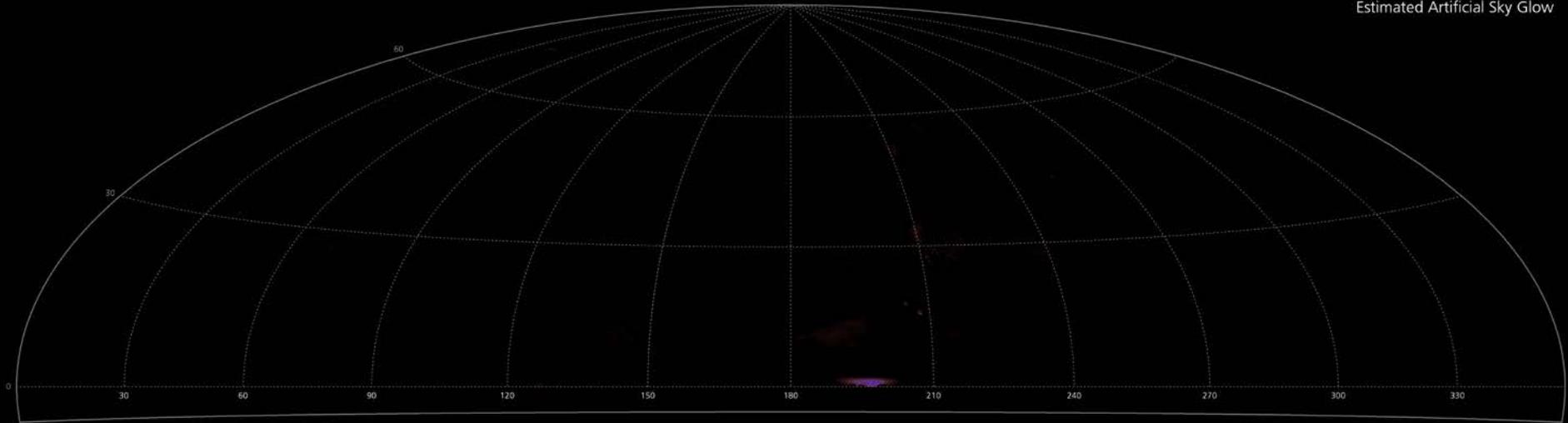
# Night Sky Quality Across the NPS

## Capitol Reef National Park



Capitol Reef National Park Burr Trail July 27, 2006 23.9 hours LMT

Estimated Artificial Sky Glow



U.S. National Park Service  
Night Skies Program

Data collected by: C Moore K Magargal  
Data processed by: J White

Hammer-Aitoff Equal Area Projection

$ALR = <0.04$

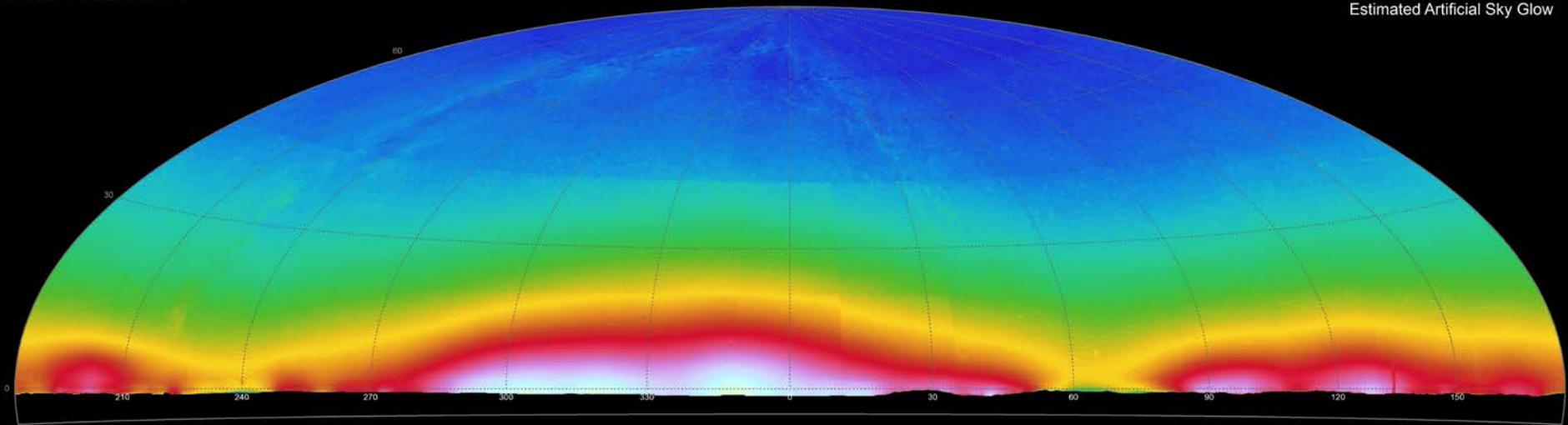
# Night Sky Quality Across the NPS

## Great Smoky Mountains National Park



Great Smoky Mountains NP Clingmans Dome October 26, 2008 19.0 hours LMT

Estimated Artificial Sky Glow



U.S. National Park Service  
Night Skies Program

Data collected by: K Magargal, M Braun, H Smith  
Data processed by: B Meadows

Hammer-Aitoff Equal Area Projection

ALR = 4.50

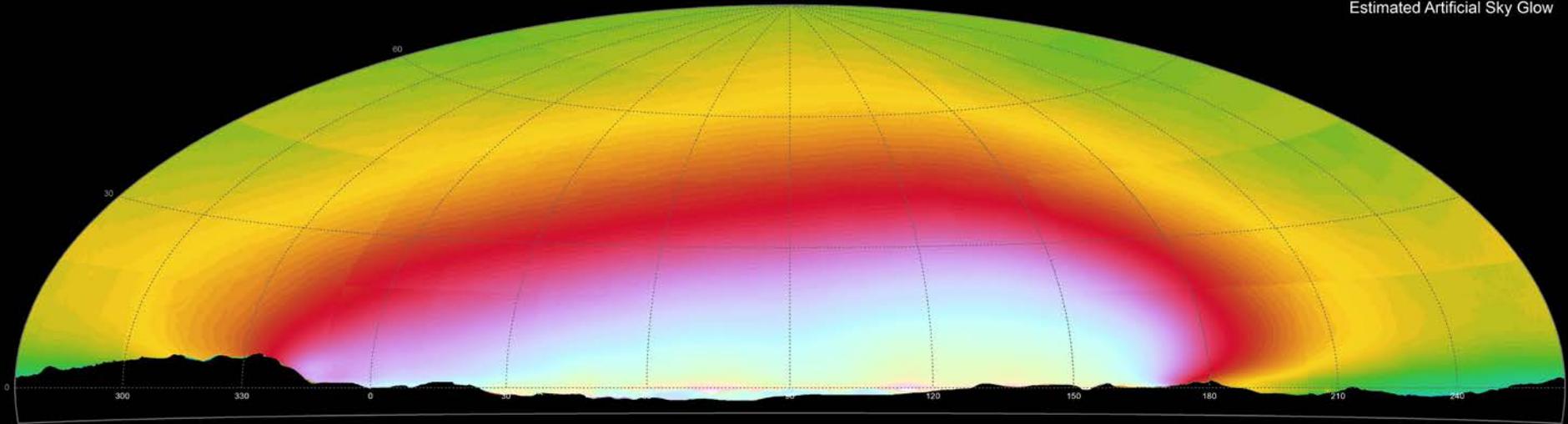
# Night Sky Quality Across the NPS

## Golden Gate National Recreation Area



Golden Gate NRA Panorama Hwy May 22, 2008 22.2 hours LMT

Estimated Artificial Sky Glow



U.S. National Park Service  
Night Skies Program

Data collected by: C Moore  
Data processed by: J White

Hammer-Aitoff Equal Area Projection

ALR = 15.76

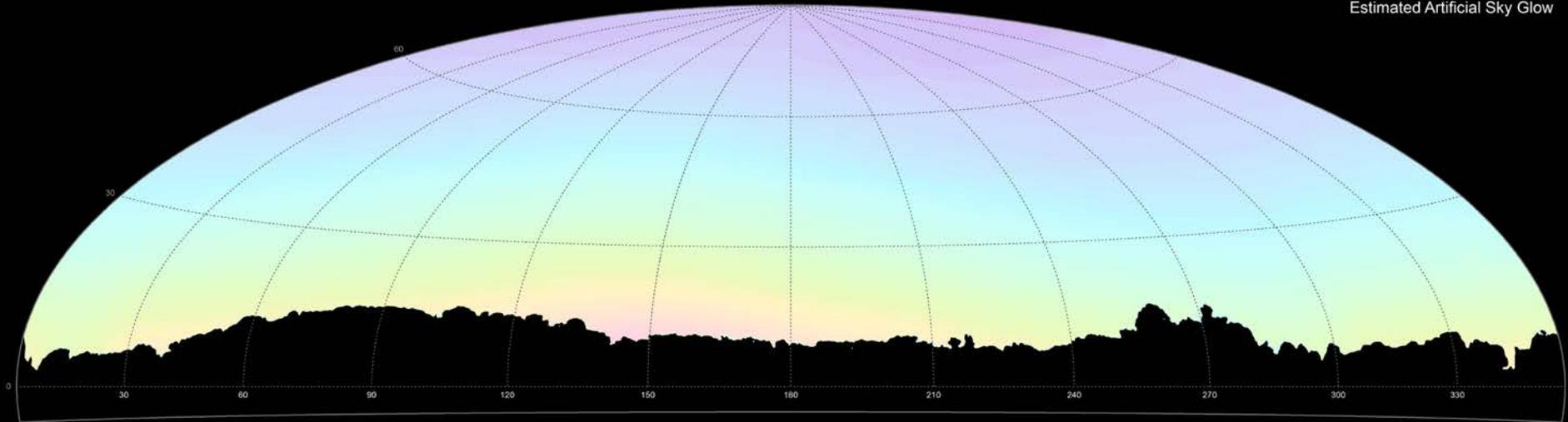
# Night Sky Quality Across the NPS

## Rock Creek Park



Rock Creek Park Military Meadow October 16, 2012 18.9 hours LMT

Estimated Artificial Sky Glow

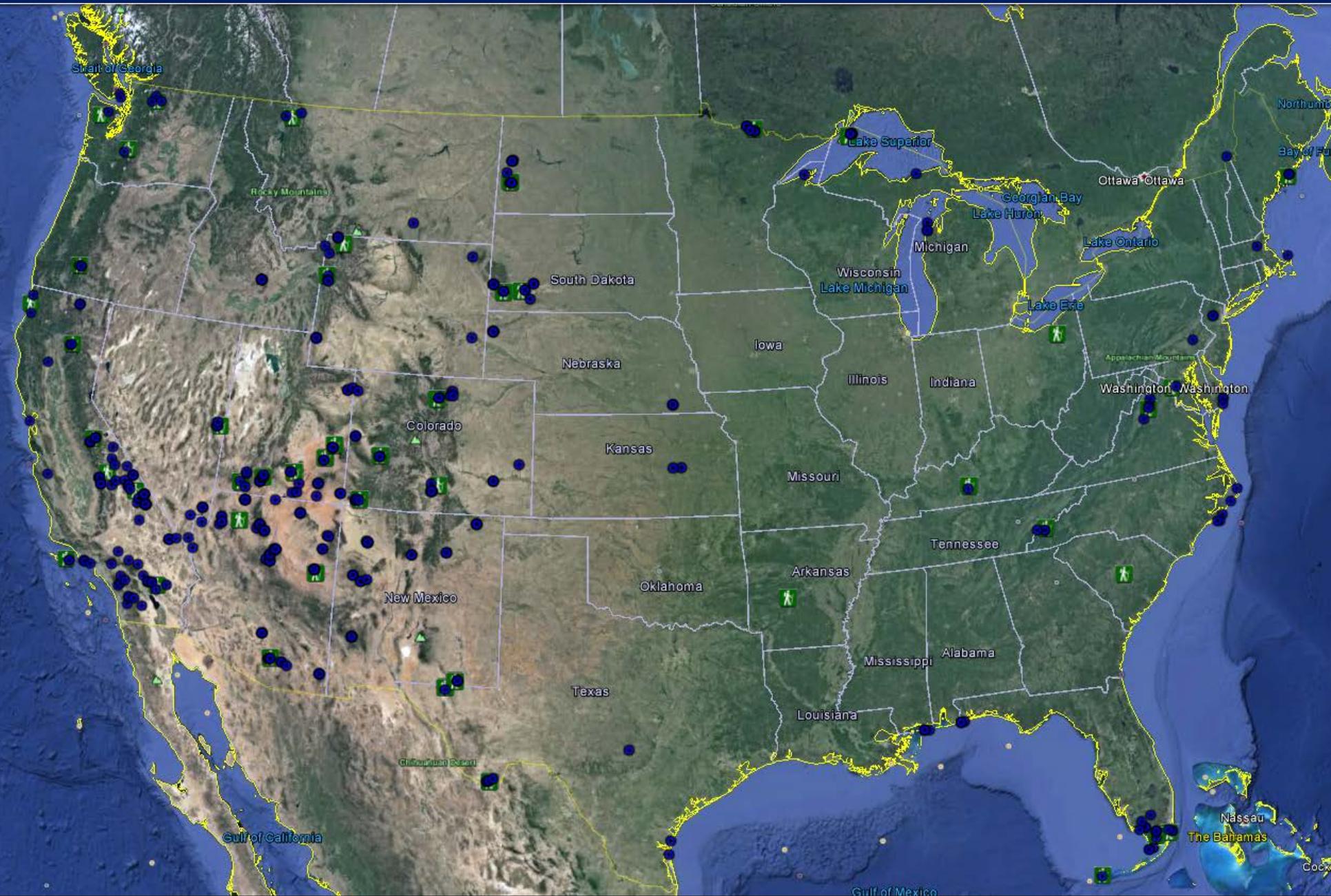


U.S. National Park Service  
Night Skies Program

Data collected by: C. Moore  
Data processed by: J. White

Hammer-Aitoff Equal Area Projection

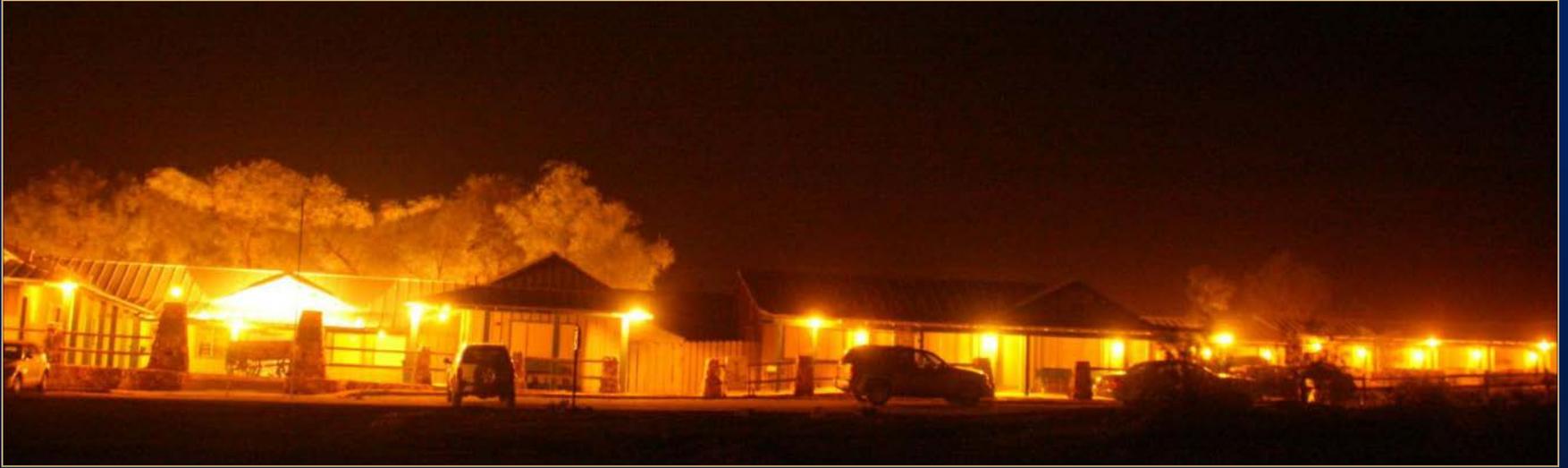
ALR = 64.43



# Big Bend National Park, Tx



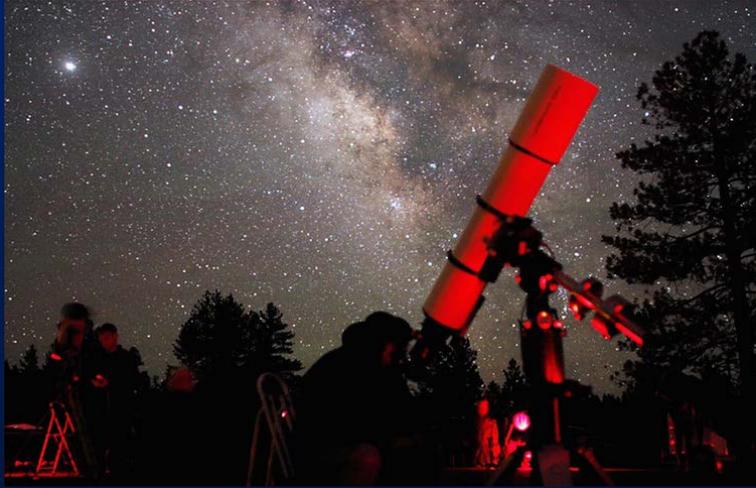
# Death Valley National Park, Ca







# Night Skies are Integral to the National Park Experience and Ecosystem



# Examples of night sky-related park contacts (2014):

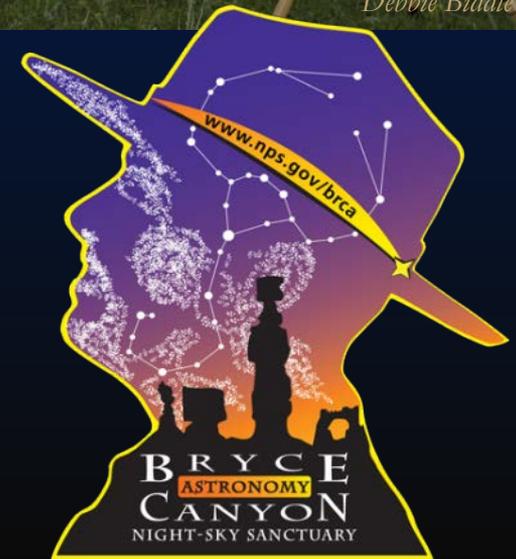
Bryce Canyon – ~30,000

Parashant – 656

Black Canyon – 6,356

Canyonlands – 761

Capitol Reef – 3,766



# Astrotourism and Economic Benefits

- Bryce Canyon (2012) – Astronomy related attendance accounted for over 50,000 visits and \$2 million contributed to local economies
- Tourism office campaigns have increased some park visitation by up to 30% (Mighty Five- Zion)



# ...Protecting the Wildlife therein

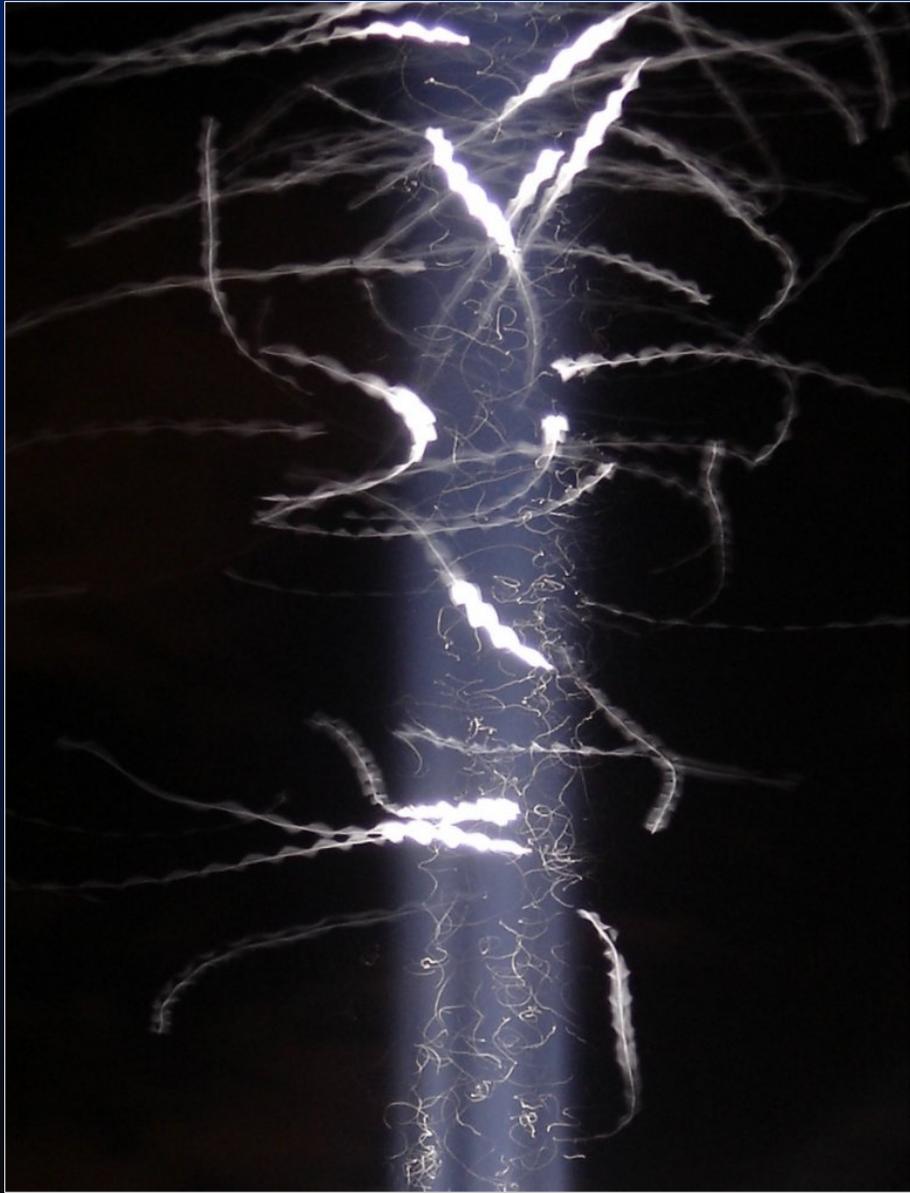


# Ecological Consequences



Photo by Kenneth Herdy, Fatal Light Awareness Program.



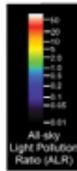


# Colorado Plateau Dark Sky Cooperative

 Popular Stargazing Sites

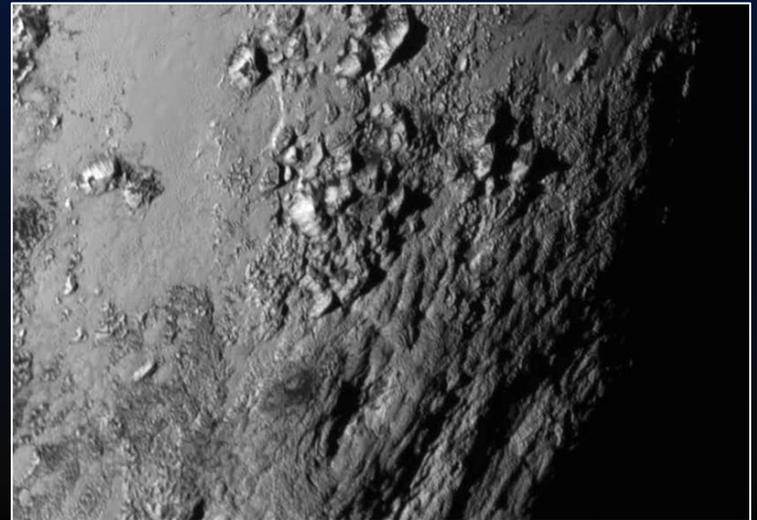
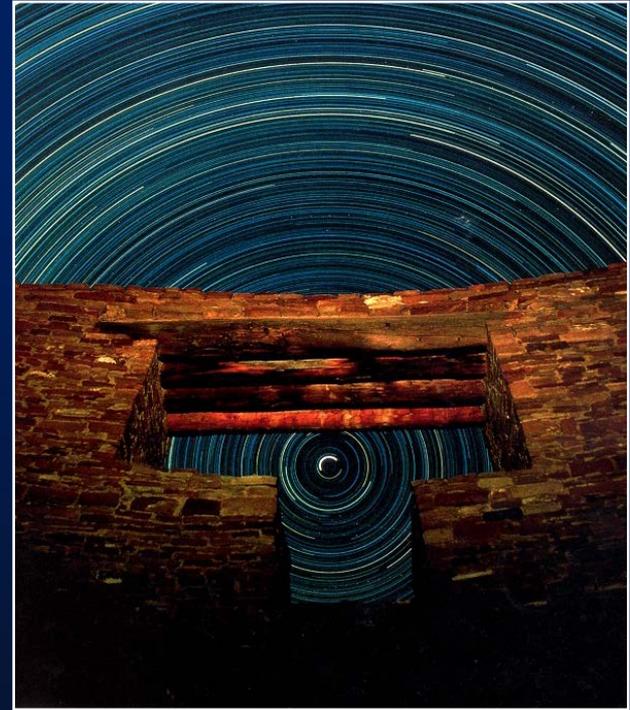
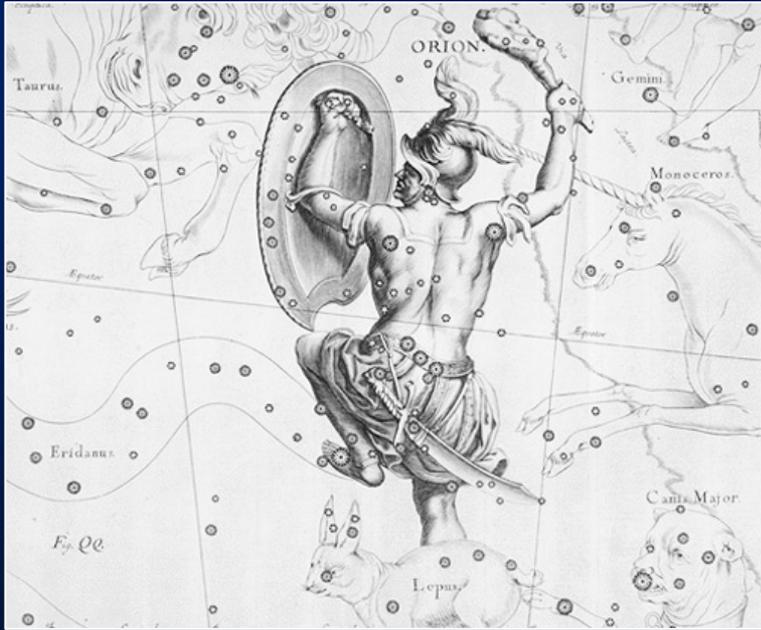
 IDA Certified Dark Sky Sites

 Pending IDA Certified Dark Sky Sites



**COLORADO PLATEAU**  
DARK SKY COOPERATIVE

# Timeless Source of Wonder



*"Unlike losing a species to extinction, topsoil to erosion, or virgin lands to development, the night sky is 100% recoverable."  
—Dan Duriscoe, 2001*



Thank You



NPS Night Skies Program - [www.nature.nps.gov/night](http://www.nature.nps.gov/night)

International Dark Sky Association - [www.darksky.org](http://www.darksky.org)

Globe at Night Campaign - [www.globeatnight.org](http://www.globeatnight.org)