

Light Pollution Matters

6%

Annual increase in artificial light at night

50%

Increase of developing breast cancer in heavily light polluted areas

97%

Americans unable to see the Milky Way at night

35,000 years

Length of documented stargazing

98 million

Number of bird deaths annually from collisions with lighted buildings

\$7 billion

Cost of energy waste in the US each year due to poorly designed lighting

180 billion

Approximate number of outdoor light fixtures in the US

Resources

Bibliography

- Brons, J., Bullough, J., & Rea, M. (2008). Outdoor site-lighting performance: A comprehensive and quantitative framework for assessing light pollution. *Lighting Research & Technology*, 40(3), 201-224. doi:10.1177/1477153508094059
- Cavanoc, M & Free Roaming Photography. (n.d.). Street Lamp [Photograph]. Used with permission of owner.
- Chepesiak, R. (2009). Missing the Dark: Health Effects of Light Pollution. *Environmental Health Perspectives*, 117(1), A20-A27. doi:10.1289/ehp.117-a20
- Cinzano, P., Falchi, F., Elvidge, C. D., & Baugh, K. E. (2000). The artificial night sky brightness mapped from DMSP satellite Operational Linescan System measurements. *Monthly Notices of the Royal Astronomical Society*, 318(3), 641-657. doi:10.1046/j.1365-8711.2000.03562.x
- Cinzano, P., Falchi, F., & Elvidge, C. D. (2001). The first World Atlas of the artificial night sky brightness. *Monthly Notices of the Royal Astronomical Society*, 328(3), 689-707. doi:10.1046/j.1365-8711.2001.04882.x
- Clanton, N. (2014). Opinion: Light pollution ... is it important? *Lighting Research & Technology*, 46(4), 4. doi:10.1177/1477153513519378
- D. Greenblatt, NASA DEVELOP National Program Virtual Poster Session Interview, (March, 2017).
- Dominoni, D. M., Borniger, J. C., & Nelson, R. J. (2016). Light at night, clocks and health: from humans to wild organisms. *Biology Letters*, 12(2), 20160015. doi:10.1098/rsbl.2016.0015
- Duriscoe, D. M. (2013). Measuring Anthropogenic Sky Glow Using a Natural Sky Brightness Model. *Publications of the Astronomical Society of the Pacific*, 125(933), 1370-1382. doi:10.1086/673888
- Falchi, F., Cinzano, P., Duriscoe, D., Kyba, C. C. M., Elvidge, C. D., Baugh, K., Furgoni, R. (2016). The new world atlas of artificial night sky brightness. *Science Advances*, 2(6), e1600377. doi:10.1126/sciadv.1600377
- Gallaway, T., Olsen, R. N., & Mitchell, D. M. (2010). The economics of global light pollution. *Ecological Economics*, 69(3), 659. doi:10.1016/j.ecolecon.2009.10.003
- Garstang, R. H. (1989). Night-sky brightness at observatories and sites. *Publications of the Astronomical Society of the Pacific*, 101(637), 306-329. doi:10.1086/132436
- Gaston, K. J., Bennie, J., Davies, T. W., & Hopkins, J. (2013). The ecological impacts of nighttime light pollution: a mechanistic appraisal: Nighttime light pollution. *Biological Reviews*, 88(4), 912-927. doi:10.1111/brev.12036
- Hermann, (2014, July 14). Street Lamp Lantern Afterglow Light. Retrieved July 31, 2017, from <https://pixabay.com/en/street-lamp-lantern-afterglow-light-392095/> (Originally photographed 2012, January 20)
- International Dark-Sky Association. (n.d.) Light Pollution. Retrieved June 21, 2017, from <http://www.darksky.org/light-pollution/>
- Longcore, T., & Rich, C. (2004). Ecological light pollution. *Frontiers in Ecology and the Environment*, 2(4), 191-198. doi:10.2307/3868314
- McGuire, R. (2014, January 4). Street Lamp Lantern Illuminate Lamp Light. Retrieved July 31, 2017, from <https://pixabay.com/en/street-lamp-lantern-illuminate-lamp-238521/>
- Navigant Consulting, Inc. (2012, January). *US Department of Energy* (United States, Department of Energy, Office of Energy Efficiency & Renewable Energy). Retrieved June 21, 2017, from <https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf>
- Ruggles, C. L., & Cotte, M. (2010). *Heritage Sites of Astronomy and Archaeoastronomy in the context of the UNESCO World Heritage Convention: A Thematic Study*. Retrieved July 13, 2017, from http://www.astronomicalheritage.org/index.php?option=com_content&view=article&id=28&Itemid=33



Prepared July 2017 for the National Park Service by the
NASA DEVELOP National Program - Wise County
Clerk of Circuit Court's Office

Veronica Warda, Ryan Avery, Steven Chao, and Stanley Yu
<http://develop.larc.nasa.gov>

in collaboration with

National Park Service, Grand Teton National Park; National Park Service,
Intermountain Region; National Park Service, Natural Sounds and Night
Skies Division; and Wyoming Stargazing

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration.

This material is based upon work supported by NASA through contract NNL16AA05C and cooperative agreement NNX14-AB60-A.

National Aeronautics and Space Administration

www.nasa.gov

NP-2017-08-975-LaRC



National Aeronautics and
Space Administration

Light Pollution
in our National Parks

www.nasa.gov

About Light Pollution

Light pollution is defined as any excessive or unwanted artificial light that obscures the view of the stars. There are many different types of light pollution (all of which are seen in Figure 4):

- ▶ **Glare:** an extreme contrast of light and dark areas in one's line of sight; often causes visual discomfort
- ▶ **Light trespass:** unwanted artificial light introduced into an area where it is unneeded or unwanted
- ▶ **Overlighting:** the excessive use of artificial lighting
- ▶ **Skyglow:** the faint glow seen in the night sky, usually over densely populated urban areas

The main factor that causes light pollution is poorly shielded outdoor lighting. In fact, in a typical unshielded light fixture, 50% of the light produced is wasted. This portion illuminates the surrounding air instead of its intended target on the ground.

Since many national parks are known for their pristine environments, light pollution from skyglow is a pertinent concern for NPS officials. This problem has become especially relevant with rapid urbanization in areas nearby the parks. With an obstructed view of the stars and galaxies, artificial skyglow threatens the visitor experience and tourism in the parks.

Fig. 2.
The Skyglow Estimation Toolbox creates maps that will help park officials better understand nighttime sky quality in the parks. >

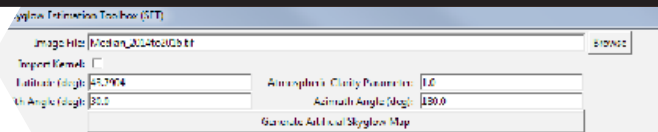


Fig. 4. Use minimum amount of lighting needed to illuminate target. In this case, excess light escapes into the sky, degrading nighttime visibility. >
© Mike Cavaroc/Free Roaming Photography

A Way Forward

In 2017, the National Park Service worked with Wyoming Stargazing and a team from the NASA DEVELOP National Program to better understand the impacts of skyglow in Grand Teton National Park in Teton County, WY. The NASA DEVELOP team created the Skyglow Estimation Toolbox (SET) that utilizes data collected by the NASA/NOAA Suomi National Polar-orbiting Partnership satellite Visible Infrared Imaging Radiometer Suite sensor Day/Night Band to calculate the effect of light scattering. The software creates Artificial Skyglow Maps that measure skyglow at various viewing angles and lines of sight in the park. This will help park officials determine the current sky quality and identify sources of light pollution that are diminishing its quality. Moreover, the data produced by SET will help government officials make informed decisions regarding lighting ordinances in Teton County.

< **Fig. 1.** An unshielded light fixture (top) as compared to a shielded one (bottom). Half of the light from unshielded fixtures is unproductive, wasting billions of dollars each year.

< **Fig. 3.** Artificial Skyglow Map for Grand Teton National Park (outlined in orange). Values are a ratio between artificial and natural sky brightness, with cooler colors indicating smaller ratios.

Raise Awareness

Although light pollution does have serious ramifications, it is a problem that can easily be reversed. As a park ranger, you have the opportunity to highlight the impacts of light pollution with park visitors:

- ▶ Discuss the impacts of light pollution, especially on the night sky and on human health, as well as the wasted energy costs
- ▶ Offer suggestions on how each park visitor can reduce light pollution
 - ▶ Install outdoor lighting only if absolutely necessary
 - ▶ Use minimum amount of lighting needed to illuminate the target
 - ▶ Ensure fixtures are properly shielded
 - ▶ Turn on lights only for the time it is needed
 - ▶ Encourage local governments to establish lighting ordinances that limit light pollution

