



Shared Stewardship: Light Pollution Lesson

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Overview

We are all committed to responsibly protecting and preserving the park's natural, cultural, and human resources.

Learning Objectives

- Students will understand the importance of light in ecosystems.
- Students will understand the dangers of artificial lights to animals and humans.
- Students will offer solutions to light pollution.

Materials Needed

- Whiteboard (or big paper) and markers
- Markers

General Outline

- 1. Why is light important?**
 - a. Ecosystems*
 - b. Species Cycles*
- 2. How can light pollute?**
 - a. Discussion*
 - b. Increase of Light Use*
 - c. Types of Light Pollution*
 - d. Effects of Light Pollution*
 - e. Light Pollution in National Parks*
- 3. Activity**
 - a. Navigate Light Pollution*
 - b. Design a Night Sky Town*

Background (for park employee benefit)

Light pollution has become an issue of increased concern in recent years, as researchers learn of the widespread impacts that artificial light has on animals throughout all ecosystems. NPS has committed to doing what it can to reduce the effects of light pollution by implementing best practices across parks, including reducing non-crucial light usage, protecting dark-dependent habitats from lights, and retrofitting necessary light to minimize its reflectance. MONO, being so close to the City of Frederick and D.C., is exposed to the impacts of light pollution.

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Procedure

1. Why is light important?

a. *Ecosystems*

i. Weather-driver¹

1. The sun warms the air, which drives the weather by creating differences in pressure, causing winds, rain patterns, storms, and ocean currents.
2. The sun drives the water cycle by warming water, making it evaporate, then moving it throughout the world through pressure differences.

ii. Main energy source for organisms²

1. Plants, algae, and cyanobacteria convert sunlight into energy through photosynthesis.
2. Plants are eaten by herbivores and omnivores, and the energy produced from sunlight is passed on through the biosphere's food chain. Sunlight fuels every living thing.
3. Warmth for life.

b. *Species Cycles*

- i. Species use the amount of daylight hours to know when to feed, mate, and perform other necessary tasks, as they are guided by seasonal changes.
 1. Reproduction: Amphibians, like frogs and toads, croak at night as part of their breeding ritual. Songbirds sing at night before mating.
 2. Predators: nocturnal animals, like owls and bats, hunt at night to mask their movements
 3. Prey: prey species hide in the darkness from hunters
 4. Migration: birds like Indigo Buntings have been found to use stars for guidance as they fly at night³
 5. Navigation: baby sea turtles follow the moonlight to the ocean
 6. Insects: attracted by light
 7. Communication: fireflies and glowworms communicate through self-generated light⁴

2. How can light pollute?

a. *Discussion*

¹ Sneideman, J.M. (2014) "A guide to the energy of the Earth."

² Harvard Graduate School of Education. "Ecosystem Curriculum."

³ All About Birds. "Indigo Bunting" https://www.allaboutbirds.org/guide/Indigo_Bunting/overview#

⁴ Longcore, T., & Rich, C. (2004) "Ecological Light Pollution."

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- i. Ask the students: what do you think the night sky at MONO looked like during the Battle of Monocacy?
 1. There is evidence that before the Industrial Revolution, cities had light pollution interfering. People could leave the cities, though, without the miles of glow interference we have now.
 2. After the Industrial Revolution, our night skies have drastically changed. You can hardly see more than a dozen stars in a city's night sky, and the effects are still felt even if you are tens of miles away from the city.
- ii. Ask the students: can you name a few major sources of artificial light?
 1. Examples: homes, office buildings, stadiums, billboards, streetlights, outdoor lights (houses), vehicles, lighthouses, boats, planes, reflection in bodies of water
- b. *Increase of Light Use*
 - i. Half of the world's population (3.8 billion people) live in cities, and 83% of the world's population (6.3 billion) lives under light-polluted skies.
 - ii. Such a big increase cannot exist without impacting the environment.
- c. *Types of Light Pollution*
 - i. Definition: inappropriate or excessive use of artificial light⁵
 - ii. Glare: disruptive light that shines horizontally
 - iii. Light trespass: unwanted shining of light onto nearby area
 - iv. Uplighting: light that is focused skyward
 - v. Skyglow: halo over inhabited areas caused by the scattering of light particles
- d. *Effects of Light Pollution*
 - i. Animals
 1. Reproduction: interrupts amphibians and songbirds nocturnal mating rituals.⁶
 2. Predators: exposes nocturnal predators.
 3. Prey: exposes prey. This may lead to drastic population decreases. Insects are drawn to light, and artificial lights can kill them. Prey animals, such as deer, have been observed to shift their movements to avoid lit areas, which may lead to isolation, impacting genetic diversity, their susceptibility to diseases, and access to resources.⁷

⁵ Drake, N. (2019) "Our nights are getting brighter, and Earth is paying the price."

⁶ International Dark Sky Association. "Light Pollution Effects on Wildlife and Ecosystems."

⁷ Bliss-Ketchum, L.L., et al. (2016) "The effect of artificial light on wildlife use of a passage structure."

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4. Migration: birds depend on seasonal light schedules to know when to migrate. Departing too early or too late due to artificial nocturnal light might make them miss ideal climate conditions for nesting, foraging, and other behaviors. Birds that depend on stars to navigate may be unable to see them
5. Navigation: baby sea turtles are confused by lights from roads and buildings
6. Communication: disrupts animals that communicate with light, like fireflies
- ii. Humans
 1. Sleep deprivation: melatonin is meant to increase at sundown and peak at midnight, regulating sleep-wake cycles, slowing metabolism, and increasing leptin, a hormone that reduces appetite.⁸
 2. Health issues: secondary effect of sleep deprivation. Obesity from altered appetite patterns, heart disease, diabetes, depression, among others
- iii. Human activities
 1. Increase carbon emissions: most electricity is powered by coal or oil. 13% of residential electricity use in the U.S. is for outdoor lighting, which emits around 15 million tons of CO₂ annually.⁹
 2. Astronomers are unable to study the night sky.
- iv. Recap video: “Light Pollution 101” [Link](#)
- e. *Light Pollution in National Parks*
 - i. MONO is close to two urban places, the City of Frederick and D.C., which causes significant light pollution to the park.
 - ii. Most national parks cannot escape the impacts of light pollution.
 - iii. NPS has a Night Sky Monitoring Database, which holds data from over 317 sites in 116 park units, as well as some areas outside the parks.¹⁰
 1. This data is collected by NPS’ Natural Sounds and Night Skies Division through NPS-pioneered portable instrumentation and techniques since 2001. Current methodologies include:¹¹
 - a. Rapid capturing the night sky in a high-resolution mosaic.

⁸ Drake, N. (2019) “Our nights are getting brighter, and Earth is paying the price.”

⁹ International Dark Sky Association. “Light Pollution Wastes Energy and Money”

¹⁰ NPS. “Night Skies: Protecting the Night”

¹¹ Duriscoe, D.M., et al. (2007) “Measuring Night-Sky Brightness with a Wide-Field CCD Camera.”

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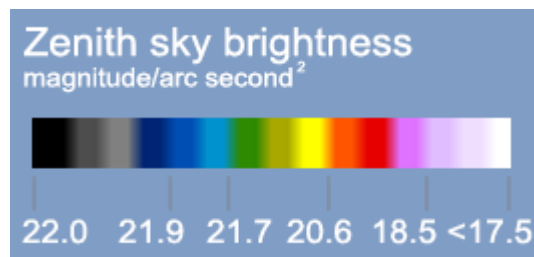
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- b. Precise measurement of sky brightness and glare across the entire celestial hemisphere.
 - c. Identification of light pollution sources.
 - d. Separation of natural and human-caused sky brightness.
 - iv. Parks are, however, natural havens in a rapidly urbanizing country. Up to 100 parks have some form of astronomy-based evening program, called “astrotourism” by many.¹²
 - v. In 2006, NPS issued a management policy documents that includes a section on lightscape management.¹³
 - 1. “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.”
 - 2. Techniques include:
 - a. Restrict use of artificial light unless crucial for safety
 - b. Use minimal-impact lighting (lamps that shine downward or can be dimmed)
 - c. Protecting dark-dependent habitats (caves) from light
 - 3. The phrase “Half the Park is After Dark” is used in many parks, including Acadia National Park in Maine, and it reflects this shift towards a more light-conscious Service.

3. Activity

a. *Navigate Light Pollution*¹⁴

- i. Ask students:
 - 1. What is the radiance for Fredrick?
 - 2. What is the radiance for D.C.?
 - 3. What makes it change?
 - 4. What would allow the soldiers on the battlefield to see the Milky way?



¹² O’Connell, K. (2018) “As Light Pollution Spreads, U.S. National Parks Become Stargazing Sanctuaries.”

¹³ NPS. “Management Policies 2006”

¹⁴ Falchi, F., et al. (2016). “The New World Atlas of the Artificial Night Sky Brightness.”

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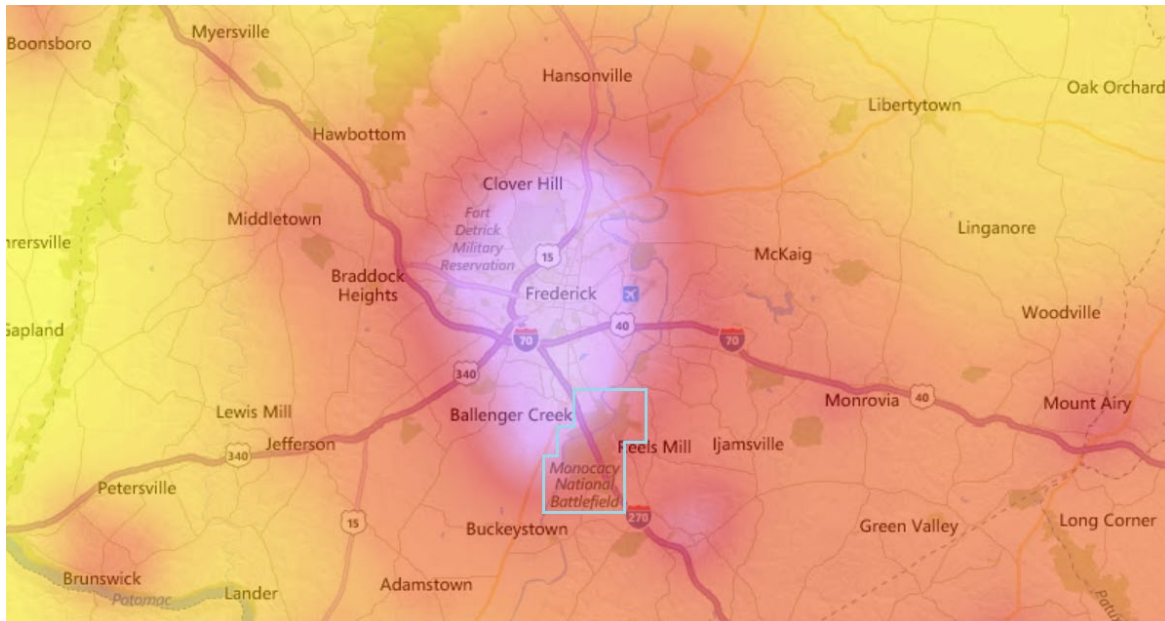
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Urban Ecology Research Learning Alliance

National Park Service
U.S. Department of the Interior
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b. *Design a Night Sky Town*

- i. Have all students work together to write a list of important light features that would make a town safer for night skies. They can draw on the whiteboard to show where certain features would be placed and how, in relation to each other. Examples¹⁵:
 1. Turn off unnecessary lights, especially indoors
 2. Lighting fixtures with full shielding
 3. Warm colored bulbs, LEDs
 - a. Red- and yellow-tint lights have long wavelengths, which are less visible to more species
 - b. Most coastal counties and municipalities in Florida have ordinances requiring long-wavelength light, shielded, and close to the ground to protect sea turtles
 4. Curfews for non-crucial lighting (stadiums)
 5. Light timers
 6. Motion-sensor light switches
 7. Host educational events
 8. Encourage astrotourism and stargazing

¹⁵ International Dark-Sky Association. (2018) "Urban Night Sky Place: Program Guidelines"

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