

Outdoor Lighting in National Parks

— Lessons Learned and Best Practices —

THE NATIONAL PARK SERVICE LIGHTING TRAINING WORKSHOP

HOSTED BY THE NATIONAL PARK SERVICE NATURAL SOUNDS AND NIGHT SKIES DIVISION





Photo credit: NPS
Front-back cover photo credit:
Wally Pacholka / Astropics.com

Why Protect National Park Night Skies?

National parks are home to some of the last remaining harbors of starlit skies and provide unparalleled opportunities for the public to experience the grandeur of a seemingly endless, starry night sky. Animals rely on natural cycles of light and dark for navigation, foraging, protection, and mating. Natural lightscapes are also a key component of wilderness quality and are integral to many cultural traditions and practices. Lighting from buildings, roads, and other facilities can disrupt these relationships.

What Policies Guide National Park Lighting?

- The National Park Service (NPS) Organic Act established the agency's mission 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 future generations." Protecting night skies is a critical component of this mission.
- 2006 NPS Management Policies guide specific 'lightscape management' practices for the use of lighting in national parks. NPS Management Policies also provide direction for promoting visitor safety and security while protecting park resources and values.
- NPS Director's Order 50 C on Public Risk Management requires superintendents to identify and mitigate risks without compromising the integrity of the environments they are charged to protect.
- The NPS Green Parks Plan articulates an overarching vision to make everything the NPS does more sustainable, including reducing energy and water consumption, limiting the waste that we generate, changing what we buy, and altering how we manage facilities.
- Executive Order 13693: Planning for Federal Sustainability in the Next Decade continues the policy, "that agencies shall increase efficiency and improve their environmental performance... To improve environmental performance and Federal sustainability, priority should first be placed on reducing energy use and cost, then on finding renewable or alternative energy solutions."

What Makes National Park Lighting Unique and Challenging?

The National Park Service is tasked with protecting night skies and enhancing visitor enjoyment while also addressing public safety, energy use, lighting costs, and the protection of natural and cultural resources.

Lighting Principles for National Parks

When taking actions that affect natural lightscapes (such as new construction, renovation, and maintenance), parks should recognize the importance of night skies and naturally dark conditions for parks and communities. Parks should balance the need for lighting with a concern for the environment. Existing management zones are often the best framework to implement this. This 'zone' approach is recommended by the Illuminating Engineers Society, and it has been used successfully in communities around the country. Finally, parks should implement best outdoor lighting management practices or mitigations.

The National Park Service recommends the following six principles for evaluating, designing and implementing outdoor lighting in national parks. Following these six principles will help parks achieve multiple objectives including those related to visitor and employee safety, security, cost savings, increasing energy efficiency, and reducing greenhouse gas emissions. These principles can also be used as a tool to help park managers involved in outreach and education with nearby communities, government agencies and other stakeholders to increase understanding of the approaches, strategies, and benefits of sustainable outdoor lighting.



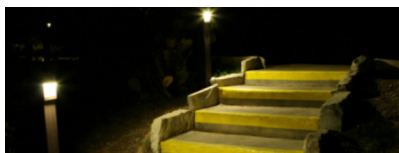
1 Light only if you need it.

Many areas in national parks require minimal or no lighting. Assess whether a light is really needed instead of just replacing bulbs and fixtures.



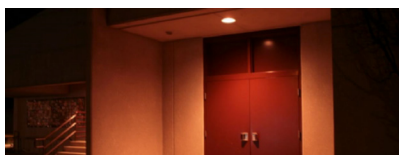
2 Light only when you need it.

Lighting may only be necessary at certain times during the night, when an area is in use, or during certain activities and special events. This can be achieved through the use of motion sensors, timers, and other controls.



3 Aim light where it is needed.

Park lighting should be shielded and directed downwards to illuminate only areas that need to be lit.



4 Use appropriate color spectra.

Different light spectra have impacts on visitor experience and park resources and values. Select a spectrum that satisfies both lighting needs and park management objectives.



5 Use the minimum amount of light necessary.

Many visual tasks in parks, such as wayfinding, often require fairly low illumination levels. As a result, the minimum amount of light necessary to meet the task should be applied.



6 Choose energy efficient lamps and fixtures.

Consider the energy efficiency of different lighting technologies, lamps, and fixtures.

Photo credit: Photos 1-4 from Dan Duriscoe, NPS; Photos 5-6 from James Crockett, NPS.

National Park Service Lighting Training Workshop



The 2015 National Park Service Lighting Training Workshop provided an opportunity for NPS staff to learn about recent developments in LED and other adaptive lighting technologies that address the unique lighting concerns in national parks, including energy efficiency, costs, public safety, and both natural and cultural resource protection. The intention was to learn through joint fact finding and identify various options, technologies, and practices to help NPS achieve sustainable outdoor lighting objectives. Reaching a consensus among participants was not an objective of the workshop, and therefore this report does not contain a consensus statement or recommended actions. A PDF of the complete Training Workshop summary is also available online: www.nps.gov/subjects/nightskies/lightinglessonslearned.htm.

Training Workshop Participants

- Argonne National Laboratory
 - Clanton & Associates
 - GFZ Potsdam German Research Center for Geosciences
 - International Association of Lighting Designers
 - Monrad Engineering
 - Musco Lighting
 - National Electronic Manufacturers Association
 - Pacific Northwest National Laboratory
 - Philips
 - Smart Outdoor Lighting Alliance
 - Triangle Associates (Facilitators, under contract with Kearns & West)
 - U.S. Bureau of Land Management
 - U.S. Department of Energy
 - U.S. Department of Transportation
 - U.S. National Park Service, Climate Change Response Program
 - U.S. National Park Service, Denver Service Center
 - U.S. National Park Service, Grand Canyon National Park
 - U.S. National Park Service, Intermountain Region Office
 - U.S. National Park Service, National Capital Region, Cultural Landscapes
 - U.S. National Park Service, Natural Sounds and Night Skies Division
 - U.S. National Park Service, Visitor and Resource Protection
 - U.S. National Park Service, Flagstaff Area Group
 - U.S. National Park Service, Lake Mead National Recreation Area
 - U.S. National Park Service, Mount Rushmore National Monument
 - University of Redlands
 - University of Southern California
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Training Workshop Agenda



Workshop Day 1

Training Session #1: Outdoor Lighting In National Parks

Training Session #2: Roadway Lighting and Public Safety

Training Session #3: Lighting Impacts on Humans and Wildlife

Training Session #4: The State of Current Lighting Technology



Workshop Day 2

Breakout Group Discussions:

- 1) Common Park Lighting
- 2) Cultural and Historic Architecture Lighting
- 3) Transportation Lighting

Full Group Discussion:

- 1) How to determine appropriate park lighting
- 2) How to stay informed of current and emerging lighting technologies



Framework: Throughout the training workshop, participants were asked to consider lighting issues in national parks in terms of:

- **Practices:** Potential updates to, and solutions for, a wide range of current park lighting practices and related challenges consistent with the NPS sustainable outdoor lighting principles.
- **Technology:** Technological solutions appropriate for addressing outdoor lighting needs in national parks.
- **Purchasing:** The process for acquiring outdoor lighting in national parks.

Photo credits: NPS

Presentation Summaries

Training Session #1: Overview of National Park Lighting

KEY TAKEAWAYS

- NPS Management Policies 4.10 require NPS to preserve the natural lightscapes of parks and minimize light that emanates from park facilities. NPS policy also requires superintendents to identify risks and mitigate those risks without compromising the integrity of the environments they are charged to protect (Director's Order 50C).
- The NPS follows a "sustainable lighting" concept which emphasizes a consideration of economic, environmental, and social needs when making lighting decisions for national parks.
- Sustainable outdoor lighting in national parks is based on six key principles for evaluating, designing, and implementing outdoor lighting.
- The NPS Denver Service Center (DSC) provides NPS-wide technical guidance on architecture in national parks through design, construction, and operations and maintenance, and incorporates professional standards in the design of outdoor lighting.



Photo credit: NPS

Why National Parks are Different, and an Overview of Authorities and Principles

Presentation by Frank Turina, NPS NSNSD; and Melinda Koslow, NPS Sustainability Office

- **Recap:** The presentation provided an overview of the NPS policy framework. Outdoor lighting directly relates to the requirements of various different NPS Management Policies (which tier directly from the NPS Organic Act) and the preservation of national park lightscapes. For example, Lightscape Management Policy 4.10 states that the NPS must preserve natural lightscapes to the "greatest extent possible," seek to "minimize light that emanates from park facilities," and restrict lighting to areas where "security, basic human safety, and specific cultural resource requirements must be met." Management Policy 8.2.5.1 on visitor safety further clarifies the NPS will "reduce or remove known hazards" yet in doing so, the NPS' "preferred actions will be those that have the least impact on park resources and values." Additionally, NPS Director's Orders clarify Management Policies for NPS managers. For example, NPS Director's Order 50C on Public Risk Management gives superintendents discretion over whether and how to balance "public recreation and safety" while ensuring national park resources are protected to the greatest extent possible. Related to these policies, the NPS identified six principles for evaluating, designing, and implementing outdoor lighting in national parks which help the NPS achieve the natural and cultural resource objectives around lightscape protection, energy efficiency, and reduction of greenhouse gases.

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- The presentation also included an overview of the purpose, objectives, and implementation of the NPS Green Parks Plan, which encourages sustainable practices in national parks including preserving outdoor values and reducing energy use while also protecting lightscapes for humans and wildlife.

Different Types of National Park Lighting

Presentation by Dan Duriscoe, NPS Natural Sounds and Night Skies Division

- **Recap:** The presentation discussed a wide range of situations where lights are used in national parks, including visitor centers, parking lots, campgrounds, park housing, and administrative areas. The NPS follows a "sustainable lighting" concept, emphasizing a blend of economic, environmental, and social needs in lighting decisions. Sustainable lighting is applied through lighting solutions tailored to natural and developed areas. For example, lighting for building entrances and egress areas should include well-shielded, motion-activated lighting that reduces unnecessary light trespass. Additionally, when replacing lights it is important to take measurements before and after installations to evaluate the effectiveness of new lighting.

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Presentation Summaries

Training Session #1: Overview of NPS lighting *continued...*



Photo credits: NPS

Introduction to the NPS Design and Construction Process

Presentation by James Crockett, NPS Denver Service Center (DSC)

- **Recap:** The presentation covered the work of the Denver Service Center (DSC) and its efforts to ensure sustainable lighting in national parks. The DSC provides NPS-wide guidance through design, construction, and operations and maintenance on facilities in national parks to preserve history, create memories, evoke emotions, and connect people to nature and national park resources. At the beginning of national park design and construction projects, the DSC selects quality architectural / engineering (A/E) and construction contractors. Construction contractors are selected on a project-by-project basis through a competitive, “best-value” process. Before projects begin, DSC provides web-based workflow guidance. During projects, DSC evaluates projects using checklists and a detailed quality assurance process that meets NPS and regulatory guidelines. The DSC workflow includes access to professional resources and standards related to night sky preservation. After projects, DSC continues to provide technical assistance on operation and maintenance issues. Through the entire design and construction process, DSC adheres to NPS and other federal sustainability guidelines that affect lighting decisions for visitor centers, gift shops, restrooms, pathways, and all lit areas of national parks. DSC also follows Green Building Council recommendations (e.g. LEED Sustainable Sites Credit 8 Light Pollution Reduction). The DSC quality assurance process confirms that the project is appropriate for the location, and sustains the NPS design ethic.

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Discussion

Participants were asked to discuss ways in which the considerations for lighting in national parks differ or are similar to other locations. Participants noted that:

- Good lighting can be inexpensive and have long-term cost savings, although the up-front costs of better lighting implementation need to be addressed.
- National parks should consider the specific time period being preserved when selecting appropriate light fixtures for cultural and historic resources.
- Differences in lighting needs (e.g. intensity, timing, color) between public and employee areas must be considered.
- A lack of national park-specific lighting standards may result in many national parks using Illuminating Engineering Society (IES) or other lighting standards not appropriate for national parks.
- Liability from poor lighting should be a consideration in lighting decisions within the context of NPS policy and guidelines.
- Lighting decisions in national parks could benefit from developing lighting mockups and models pre-installation and feedback from successful lighting projects post-installation.

Participant discussions revealed lighting considerations unique to national parks, such as buildings with decades-old light fixtures and ways that timers and sensors could address special lighting needs.

Presentation Summaries

Training Session #2: Safety, Security, and Transportation

KEY TAKEAWAYS

- Public safety staff in national parks address some of the same incidents found in cities and poor lighting can make responding to such incidents more difficult.
- NPS, U.S. DOT, state and municipal regulations, policies and codes affect night sky protection in national parks. Additionally, AASHTO guidelines may not be appropriate for park roads.
- Improved intersection, roadway, and signage designs can reduce the need for lighting and reduce the number of roadway accidents.



Photo credit: John Evans, NPS



Photo credit: Dan Duriscoe, NPS

Law Enforcement and Public Safety Concerns

Presentation by John Evans, Branch Chief of Security and Intelligence, NPS

- **Recap:** The presentation addressed the issues faced by national park public safety staff while working in dark environments. Lighting is critical to park rangers who protect life, property, and safety – the primary security priority at national parks. Some national parks are like small cities during peak visitor seasons, and public safety staff handle situations similar to cities such as thefts, fights, car stops, and vehicle crashes. High levels of lighting can provide a false sense of security while potentially minimizing actual security. Improper lighting makes responding to law enforcement incidents more difficult. For example, improper lighting makes it hard for public safety staff to identify potential threats, differentiate between fluids at crash sites, conduct search and rescue operations, and collect high quality evidence from security camera footage. *Contact Information:* john_evans@nps.gov

Transportation Lighting and Design Elements

Presentation by Aaron Hastings, Volpe Transportation Center, DOT

- **Recap:** The presentation included an overview of federal, state, and municipal guidance and regulations for reducing light trespass from NPS roads, and design strategies that lower roadway lighting levels. At the federal level, roadway guidance includes the NPS Park Road Standards (1984), which state that roads should be “laid lightly on the land.” The U.S. DOT Federal Land Highway Program and the U.S. DOT Federal Highway Administration also have lighting standards that affect national parks, both of which rely upon the Roadway Lighting Design Guide from the American Association of State Highway Transportation Officials (AASHTO). The presentation included a case study of lighting standards from Utah, including design specifications for highway luminaires and installation specifications for highway lighting systems, as well as a policy that refers back to the AASHTO Roadway Lighting Design Guide. Municipal lighting requirements can also affect national parks; for example, Moab, near Arches NP, has a requirement for shielded and downward directed lights, and Springdale, UT near Zion NP, has a lighting code to “encourage outdoor lighting practices that will minimize light pollution, glare, light trespass and sky glow” requiring full cut-off fixtures for lights. The presentation also outlined intersection and roadway designs that can reduce the need for lighting and improve safety. These include reducing speeds and increasing visibility through visual cues, signage, physical elements, and dimming technologies; and alerting motorists to vulnerable road users. *Contact Information:* aaron_hastings@dot.gov

Discussion

Participants were asked to discuss public safety and the importance of public security when considering appropriate lighting in national parks. Participants suggested that a warranting study needs to be done before lighting is installed on park roadways. Standards like AASHTO are often absolutes, when, in fact, lighting is relative. Often, less light will create more visual acuity for motorists and pedestrians. Participants examined jurisdictional responsibilities over roadways in and near national parks, noting that many national parks are traversed and impacted by federal highways. Participants considered whether AASHTO standards are appropriate for national parks and noted that AASHTO guidance states that park roads often have different requirements and objectives than other areas. Participants also acknowledged the importance of proper signage lighting and reflectors. Signs are now very reflective, working so well that they produce a lot of glare from vehicles with modern high beam headlights. Today, low beams are often not angled properly, and high beams are too bright for conventional signage. Signs may need to be lowered to make them more visible with low beams. Dual purpose lighting might be needed in national parks to adapt to certain situations. There is an overarching need for national parks to ensure the brightest lights are focused on the information national park users and staff need to see at any given time.

Presentation Summaries

Training Session #3: Wildlife and Human Health

KEY TAKEAWAYS

- It is important for national parks to protect natural lightscapes and consider the impacts of lighting on all species.
- Public agencies and health organizations increasingly recognize light as a health concern.
- Lighting, in particular ultraviolet and blue spectrum lighting, can disrupt the circadian rhythms of species in all environments, affecting their hunting/feeding, reproductive, seasonal adaptation, and migration patterns.
- The NPS Public Health Program addresses a wide range of public health issues related to national parks – of which lighting is an area of emerging interest.
- Recent research has expanded our understanding of how lighting affects human circadian rhythms, related sleep patterns, and overall human health.



Photo credit: USGS

Impacts of Lighting on Wildlife

Presentation by Travis Longcore, University of Southern California

- **Recap:** The presentation addressed the impacts of lighting on wildlife and the importance of protecting natural lightscapes. Lighting, in particular ultraviolet and blue spectrum light, can disrupt the circadian rhythms of all species, many of which are sensitive to significantly lower light levels than humans. Lighting also impacts ecosystems. Examples include:
 - Beaches: Sea turtles move away from the darkest horizon when they hatch and lighting disrupts this behavior. Lighting also disrupts beach mouse foraging patterns.
 - Deserts: Small amounts of light propagate in open spaces such as deserts. Deserts also have many nocturnal species that are particularly sensitive to light.
 - Wetlands: Fish movement in streams and the vertical movement of zooplankton in wetlands are disrupted by lights.
 - Oceans: Sea birds are attracted to ship lighting since they associate lights with food.
 - Grasslands: Lights can interfere with firefly reproduction and the nesting patterns of shorebirds. Floral production also changes under lighting at night.
 - Forests: Lighting alters the hunting patterns of flying squirrels in forests.
 - Mountains: Since mountains are at an angle their environments are particularly vulnerable to lighting in surrounding lowlands.
 - Arctic regions: Reindeer eyes cannot adapt to the extreme seasonal lighting changes of arctic regions if exposed to lighting in the winter.
 - Urban areas: Since cities have more human activity during the day, species move their activities to night when they are more exposed to lighting.

The presentation concluded with a discussion of research showing that lighting may cause habitat fragmentation and extinctions of specialist species, affect species evolution, advantage predator species, and alter foraging patterns for some species. To mitigate these impacts, national parks should avoid ultraviolet and blue spectrum light, consider the impacts of green, yellow, and red lights on different species, and pay closer overall attention to lighting spectrum.

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Impacts of Lighting on Humans

Presentation by George Larsen, NPS

- **Recap:** The presentation provided an overview of the role and organizational structure of the NPS Public Health Program (PHP). PHP consults with national park staff on a wide range of public health issues, including response to infectious disease cases, data-sharing, and management of any health issues related to NPS facilities and infrastructure. The NPS Office of Risk Management works with the NPS PHP on visitor and employee health issues. Additionally, PHP's Healthy Parks Healthy People Program utilizes national parks as an important public health asset. PHP considers outdoor lighting a "special/emerging" public health issue.

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Presentation Summaries

Training Session #3: Wildlife and Human Health *continued...*



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Impacts of Lighting on Park Visitors

Presentation by Jeremy White, NPS Natural Sounds and Night Skies Division

- **Recap:** The presentation reviewed the growing body of research showing the effects of lighting on human health. Associations have been found between light at night and certain cancers, heart disease, oxidative stress, and immunological modulation. The physiological mechanisms for these associations are becoming increasingly clear. In 2002 the intrinsically photosensitive retinal ganglion cell (ipRGC) was discovered. Unlike rod and cone cells, ipRGC do not contribute directly to visual perception (though they do influence pupil dilation and visual adaptation). ipRGC are maximally sensitive to light with wavelengths from 450-480 nm (blue), and they influence a wide array of physiological responses including regulation of wake-sleep cycles. In particular, ipRGC signalling suppresses melatonin production. Low melatonin levels are known to elevate cancer risk, promote tumor growth, and decrease the effectiveness of cancer drug treatments. Melatonin also is a highly effective antioxidant. Uncovering the full range of health consequences of ipRGC stimulation at night is an active area of research, and the emerging scientific evidence has stimulated the marketing of many products to reduce exposure to blue light at night.

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Discussion

Participants discussed how the effects of light on humans and wildlife should be considered when acquiring outdoor lighting for national parks. Participants noted that some visitors are habituated to bright urban lighting, indicating that more dark sky education may be needed. They also noted that visitors may expect dark skies in large, rural national parks in the West, but not in urban national parks, so the NPS should consider differences in lighting expectations of visitors in national park settings. Many participants mentioned lighting opportunities, such as the co-benefits of lighting that protects both nocturnal species and human enjoyment of the dark sky, the chance to set NPS-wide lighting standards, and the ability to leverage the scale and influence of the NPS for positive lighting change nationwide. One participant noted the NPS could develop a matrix of lighting priorities for each national park, and another noted the NPS could be a catalyst for making good lighting practices mainstream in the U.S., just as it did for low-water bathroom technology. Finally, participants noted that national park lighting does not necessarily have to match the lighting levels of surrounding areas, and national parks can act as “dark sky islands” in urban areas.



Photo credit: NPS

Presentation Summaries

Training Session #4: Lighting Technologies

KEY TAKEAWAYS

- Lighting technology has become more efficient and customizable. However, lights can contribute to sky glow when improperly installed or used.
- Before utilizing new lighting technology, the NPS should first consider the information that needs to be conveyed to visitors and staff through the use of lighting.
- National parks can manage the amount and distribution of light using several tools and models. They must first identify their night sky goals, criteria, and zones.
- National parks should consider light direction, light intensity over time, and light color and spectral composition when applying new lighting technology.
- Different light spectra are appropriate for protecting different species, human experience, and dark sky needs.



Photo credit: NPS

History of Lighting Technology

Presentation by Joe Crookham, Musco Lighting

- **Recap:** The presentation addressed changes to lighting technology, the role of lighting in different buildings and monuments, and lighting challenges encountered by Musco Lighting. Lighting has become more efficient and customizable over time, notably with recent advances in LED lighting. Light can be misused, lost, contribute to sky glow, and waste energy if lights and fixtures are improperly installed and used. It is important to identify the purpose of a light and install appropriate technology to minimize lost light and wasted energy. Musco Lighting has worked with the NPS at Mt. Rushmore, the Washington Monument, the White House, and other locations to reduce light trespass, save energy, and protect park resources and values.

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Lighting Technology, Types of Lighting, and Best Use Situations

Presentation by Nancy Clanton, Clanton and Associates

- **Recap:** The presentation covered strategies for addressing common lighting issues in national parks through computer modeling, improved lighting criteria, and lighting controls. NPS should use additional measures for effective lighting such as luminance-based criteria, contrast, and visibility. The amount of light necessary can be reduced by increasing contrast and other factors affecting visibility. NPS should provide important information like night sky goals, lighting zones, management objectives and desired conditions to assist lighting experts in designing and implementing lighting in parks. As a resource, national parks might refer to Model Lighting Ordinance developed by the IDA and Illuminating Engineering Society (IES) or the Backlight, Uplight, and Glare (BUG) rating system, developed by the IES, which rates light distribution. Lighting criteria might include safety, environment, budget, and aesthetic character.

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Color Spectral Composition, Sensors and Timers

Presentation by Susanne Seitinger, Philips

- **Recap:** The presentation addressed different lighting technologies that may be appropriate for national parks. National parks should consider light direction, light intensity over time, light color and spectral composition when applying new lighting technology. National parks could consider light dimming schedules, lighting controls, and technology that reports the condition and energy use of lights without the need for physical inspections. It is also important to recognize that color (i.e. temperature, mix, and spectrum) can affect humans and wildlife. For example, health issues may result from exposure to blue spectrum light. Additionally, research is underway which identifies the light spectra appropriate for different lighting priorities such as species protection, human experience, and dark skies.

The presentation included the following suggestions: 1) exploit new LED light sources, 2) direct the light, 3) deliver light where and when you need it, 4) monitor lights, 5) study the appropriate lighting spectrum and system efficacy, 6) analyze human tasks carefully to ensure the appropriate safety and atmosphere with lighting, 7) design lights with visitors, landscapes, and wildlife in mind, and 8) create holistic design approaches and lighting master plans.

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Presentation Summaries

Training Session #4: Lighting Technologies *continued...*



Photo credit: Susanne Seitingner, Philips

Discussion

Participants discussed a variety of topics related to lighting technologies. They also provided measures that NPS should consider to ensure lighting is consistent with NPS outdoor lighting principles, including:

1. What amount of lighting control, color, intensity, or energy efficiency is appropriate for any given national park?
2. How can NPS use the six NPS lighting principles to educate adjacent contributors to sky glow?
3. What are the maintenance and operational needs of new lighting systems?
4. How does the NPS determine where lights can go?
5. What are the quantifiable lighting thresholds national parks should use?

In response to a question about the recommended spectra for security cameras, participants noted that infrared cameras are not as clear as full spectrum cameras, and in developing camera lighting, users must consider the kind of data they need to extract. Participants noted that recent research demonstrates that continuous and discrete light spectra are perceived differently.



Photo credit: NPS, Scott McFarland

Breakout Group Summary: Common Park Lighting

Common park lighting sources include park residences, visitor centers, campground restrooms and kiosks, parking lots, arenas, amphitheaters, pathways, task lighting, maintenance yards, and boat ramps.

The following aspects of common lighting in national parks were discussed.



What's Working

Breakout group participants noted approaches and park lighting practices that are working in national parks. The following ideas were emphasized:

- The systematic approach taken by national parks to inventory their exterior lighting. The Grand Canyon was cited as a good example of a systematic lighting inventory. Participants detailed how the NPS should properly size lighting inventories for different national parks according to their capabilities; learn to create inventory tools that can be customized; explore how to involve concessionaires in the development of lighting inventories, particularly for lighting retrofits; study how and when to utilize GPS, pictures, and remote sensing; and study how to make dark sky designation a priority in lighting inventories.
- The NPS commitment to protect night skies, cultural, and natural resources from the effects of outdoor lighting, demonstrated through the support of the Natural Sounds & Night Skies Division.
- NPS outreach to other agencies and the public about night sky practices, often in response to other agencies asking the NPS about night sky practices and sky quality metrics. This encompasses the effective use of social media as well as lighting and efficiency requirements in concessions and contracts.
- NPS comments on actions proposed by other agencies through the National Environmental Policy Act (NEPA) process.



Photo credits:
James Crockett, NPS

What Needs Improvement

The following ideas were highlighted by the breakout groups:

- Light trespass from restroom lighting at night, including reduction of light trespass from both interior and exterior restroom lighting, and unshielded lights in campgrounds, in general.
- Procurement processes for lighting equipment, in particular how to improve NPS procurement and contracting to make it easier to purchase park friendly lighting equipment. This includes providing alternative sources for procurement of appropriate lighting.
- Describing the NPS lighting goals and specifications around concepts such as “sky glow.” Parks should articulate goals and objectives in measurable terms like total lumens, lumens per acre, percent of blue light, and other metrics.
- Attention to differing lighting needs of both small and big national parks. Big national parks might have more resources than small national parks. Consider different lighting decision-making paths for national parks of different sizes, such as a “prescriptive” path for some, and a “performance” path for others.
- Consideration of how parks can reduce the need for outdoor lighting, such as turning stairs into ramps and providing more contrast between architectural features. Look at architectural improvements before adding more light.
- Staff knowledge of existing lighting in parks. Renewed focus is needed on the purpose of each light, how they are controlled, which ones should be replaced or removed, and how to describe, assess, and measure light impacts. NPS should develop protocols and methodologies to assess how changes in lighting conditions will affect park resources and values.



Photo credit:
Dan Duriscoe, NPS

Breakout Group Summary: Common Park Lighting



Challenges

Participants identified common lighting challenges in national parks. Lighting for planned versus unplanned events was discussed — for example, a planned construction project versus an unplanned search and rescue operation. Additional challenges mentioned included implementation of IES guidelines on construction lighting, finding good specifications for temporary lighting, and inclusion of lighting in site-specific safety plans to ensure enforcement.



Potential Solutions

Participants identified various potential solutions for applying sustainable outdoor lighting principles to common lighting in national parks.

- Keep lighting solutions simple. Take advantage of economies of scale by using common products and components rather than using numerous varieties of lamps and fixtures that have different maintenance requirements. And aim for simplicity in the form, fit, function, design, operation, and commissioning of lighting product, in part for ease of staff use.
- Provide guidance for how to approach unique park lighting situations. Do not just copy best practices but also find opportunities to give systemwide guidance on national park-specific situations.
- Develop methodologies to assess whether light is needed or wanted and the thresholds for how this is determined. Remote sensing technology could be used.
- Understand and define sensitive areas and special considerations in national parks to prevent harmful light in sensitive wildlife habitat and other areas.
- Pull together interdisciplinary teams in national parks planning. For example, involve stakeholders in lighting decisions.
- Consider that not all lights need to be replaced and, if replacement is needed, understand the proper placement and amount of light required.
- Use lighting controls so there is the right amount of lighting over the right amount of time. For example, the state of California requires that nighttime park lighting (both state and local) be dimmed.
- Develop protocols for how lighting inventories are conducted, such as tracking GPS coordinates of lights, taking pictures, and mapping of light locations.



Photo credits:
Scott McFarland, NPS

Breakout Group Summary: Transportation Lighting

The following aspects of transportation lighting in national parks were discussed.

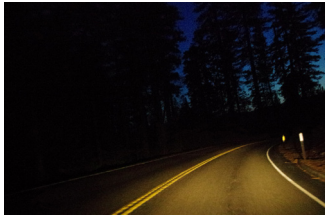


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Photo credit: NPS

What's Working

Participants highlighted several national park transportation lighting practices that are working in national parks. These include the use of partial cutoff (PC) amber lights, full cutoff fixtures, timers and motion sensors, improved lighting placement for turtles at coastal national parks, and current NPS guidelines which state that new roadways should “lay lightly on the land.” The following were also observed:

- The many unlit NPS roads. It is a much bigger step to go from no light to one light, than to go from one light to two lights. Relatedly, the NPS is already utilizing high contrast paints along roads, retroreflectors, speedbumps, and raised crosswalks in some areas.
- Many national parks have effectively identified zones of different lighting needs.

What Needs Improvement

Participants identified national park transportation lighting practices that need improvement. Specifics include the lack of documentation on transportation lights, controls, and maintenance, and the following concerns:

- Legacy lights. Many national parks have old lights and fixtures and current staff need more information about their purpose and function or how they are controlled. Additionally, it can be difficult to replace historic lighting due to elements of the National Historic Preservation Act.
- Energy and cost efficiency as the sole driver of light replacements and luminaire choice. Other important factors such as wavelength and spectrum are often not taken into account.
- Lack of communication between national parks, lighting authorities, and neighboring jurisdictions about light installations.
- Inconsistent and uneven illumination of areas which create safety hazards. Lighting needs to be carefully planned on roadways to maximize safety and visual acuity.
- Abrupt transitions in lighting between different areas (e.g. brightly lit parking lot and unlit walkway) can affect night vision and reduce visibility. Transition lighting should be implemented to avoid abrupt changes in lighting levels.

Potential Solutions

Participants identified the following potential solutions for applying sustainable outdoor lighting principles to roadway lighting in national parks:

- Learn and gather data from the national parks that have already implemented lighting retrofits. Find out from these national parks how night lighting has changed and impacted roadway safety. Incorporate a periodic review of the effectiveness of lighting retrofits.
- Use as little short-wavelength light as possible to reduce the effects of transportation lighting on visitors and wildlife.
- Consider how to light areas where pedestrians cross the roadways, including new crosswalk technologies, and conduct a task analysis for areas with conflicting modes of transportation, identifying how to improve lighting in these areas.

Ideas for Working with Stakeholders

Breakout group participants described ways to work with stakeholders to improve national park transportation lighting:

- Find model national parks needing better roadway lighting and identify their stakeholders. For example, Great Basin National Park has an observatory and could be a model for bringing stakeholders together on night sky issues.
- Work with concessionaires and surrounding communities and communicate how NPS lighting priorities help preserve the economic value of the night sky resources around national parks.
- Encourage NPS staff to attend meetings where state, other federal partners, and law enforcement might be involved in developing lighting policies, guidelines, and standards that affect national parks.

Breakout Group Summary:

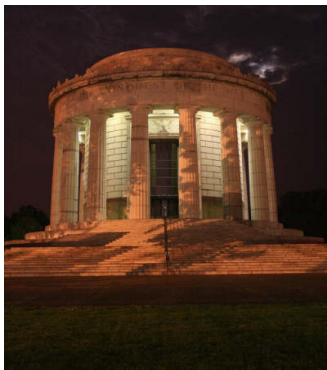
Architectural & Cultural Resources Lighting

The following aspects of architectural and cultural resources lighting in national parks were discussed.



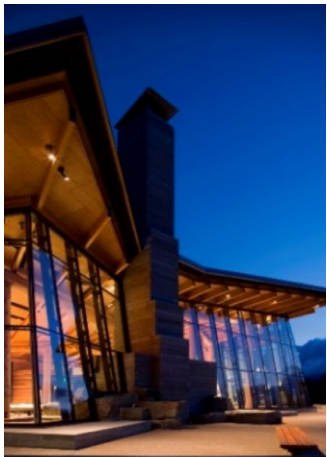
What's Working

Participants highlighted several national park architectural and cultural resources lighting practices that are currently working in national parks. Large western national parks and some smaller national parks, such as Mt. Rushmore National Memorial, have had success preserving the historic character of their lighting by using an interdisciplinary approach to designing their lighting retrofits. Additionally, national parks have made improvements in the energy and cost efficiency of their lighting.



What Needs Improvement

In discussing the aspects of national park architectural and cultural resources lighting that need improvement, participants noted that many national parks have not taken an interdisciplinary approach to lighting retrofits and management and that lighting considerations have not been made an integral part of national park planning processes. They also identified that current lighting standards, such as International Dark Sky Association standards, do not fully address lighting needs for national parks and national park managers have difficulty following them. National parks need guidelines and an understanding of their priorities, concrete examples from other national parks, knowledge of where to purchase appropriate lighting, and to balance the needs of short and long-term projects. Participants additionally noted that national park decision-makers need more information from NPS-wide lighting surveys or inventories and a clearinghouse for lighting best management practices.



Potential Solutions

- Work with cultural resource specialists on how to preserve national park cultural resource values while achieving the six NPS lighting principles. Education is needed to apply the principles without sacrificing architectural integrity.
- Consider longevity and economic sustainability in lighting fixtures.
- Establish standards and guidelines, capturing lessons learned from national parks. Consider the level of specificity needed in national park lighting standards versus lighting guidelines.
- Encourage coordination among facility managers, lighting specialists, and cultural resource experts at the national park and regional office level.
- Consider establishing an interdisciplinary workgroup to work through architectural and cultural resources lighting issues.

Photo credits: NPS

Working with Stakeholders

In reviewing ways national parks can work with different stakeholders on architectural and cultural resources lighting, it was suggested that national parks identify the priorities and resources available to national park superintendents and work with concessionaires and facility managers. For outside resources, participants proposed coordinating and connecting with universities and other outside stakeholders to compile a database of lighting treatments in national parks. It was noted that national parks could find ways to better attract partners by demonstrating the long-term benefits of lighting retrofits in national parks.

Questions for Lighting Projects

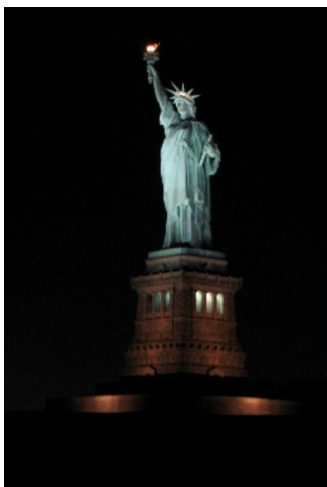


Photo credits: NPS

Using information learned during the day 1 presentations, breakout group discussions, and their own experiences, participants identified the following questions for NPS staff to consider for all outdoor lighting projects:

- 1) Do you have an existing lighting inventory?
- 2) What is the information you are trying to get by lighting this area?
- 3) What is the objective of lighting this area?
- 4) Is this a typical situation and is this a situation that occurs often, or is this a unique situation? (Example: A typical situation might be replacing a restroom light, while a unique situation might be lighting a specific high crime area)
- 5) In what management zone is this light located?
- 6) What resources are you trying to protect?
- 7) How many people use this area?
- 8) How is the area being used?
- 9) What hardware meets the specific project needs and what hardware is available?
- 10) Is this an historic resource, an historic lighting feature, or an historic building?
- 11) Have you already had an interdisciplinary discussion about this (i.e. have you talked to a facility manager, determined if there are endangered species known in this area, etc.)?
- 12) Is this a light that needs to be on all night? (Note: This relates to lighting controls)

Additional Questions For Monuments and High Crime Areas

The following questions were identified, in addition to those listed above, for projects with unique and specific objectives, such as monuments, high crime areas, etc.

- 1) Is this a situation that NPS initiated or some other situation involving lights from outside sources (such as camp lights, bike lights, or other lights that people bring into parks)?
- 2) How does this lighting project integrate with the existing design process?
- 3) Would this project trigger consultation (with SHPO, THPO etc.)?

Other Ideas for Consideration

Participants additionally identified the following ideas for NPS' consideration:

- Build a database of models for lighting in each park – the good, bad, and the ugly.
- Send a survey to national parks and make sure the survey incorporates the necessary questions about lighting.
- Establish a protocol for how to conduct a lighting inventory.
- Consider lighting as one aspect of good facility design.
- Consider both long-term and short-term lighting needs.

Statement from Natural Sounds and Night Skies Division



Gazing at the night sky with the light band of the Milky Way streaking overhead is a quintessential experience for many national park visitors and therefore, protecting night skies is a formative part of our obligation under the National Park Service Organic Act. In addition to the superlative scenic quality and opportunities for night time recreation they provide our visitors, night skies are also important natural, cultural, and historic resources in national parks and fundamental to wilderness character and values. Furthermore, protecting night skies can also provide tangible economic benefits to both parks and neighboring communities.



Photo credits: NPS

For example, naturally dark environments are essential for many vital biological and physiological functions in humans and wildlife. Natural cycles of light and dark greatly influence our circadian rhythm, the body's internal clock which regulates vital biological activities. Disruptions of these natural cycles can have adverse effects on sleep, predator/ prey relationships, reproduction, navigation and migration, feeding, immune response, and other natural processes. Similarly, night skies are also part of the cultural and historic resources preserved by the National Park Service; providing meaning and inspiration that connects us to people, places and experiences of days long past. From Native American use of constellations in sacred rituals, myths and legends to the escape routes used by African American slaves in the underground railroad as depicted at Harriet Tubman Underground Railroad National Historical Park, to understanding the complexities of ancient Puebloan societies at Chaco Culture National Historical Park, the night sky is a timeless resource important to many people, cultures, and religions. Some of the most pristine, star-filled skies are preserved in national parks.

In passing the Wilderness Act, Congress recognized the value of preserving “an area where the earth and its community of life are untrammelled by man, where man himself is a visitor who does not remain.” Star lit skies, without the glare of artificial light, are important elements of wilderness character and national parks are among the few remaining places where they can be seen. The boundless expanse of darkness, blanketed with glittering stars tumbling over each other for as far as the eye can see, instills a breathtaking sense of awe and wonderment that is difficult to match – and therefore, not surprisingly, night sky programming is fast becoming one the most popular visitor programs offered in national parks. Naturally dark skies also provide opportunities for local economic growth through astronomy based tourism such as night sky festivals, star parties and regular evening stargazing programs, now commonplace in many national parks. Even national parks near urban areas are attracting record numbers of tourists interested in learning about night skies and participating in evening based recreation and interpretive programming.

Statement from Natural Sounds and Night Skies Division *continued...*



Photo credits Jeff Zylland, NPS



Photo credit: Jeremy White, NPS

Outdoor light from park facilities and other sources is having a profound effect on our ability to see the stars, planets and other celestial features. Light from distant sources can reach far into national parks and even remote wilderness areas; yet parks also need outdoor lighting and sometimes a lot of it. Fortunately, the solution to this inherent problem is often fast, easy, effective and comparatively inexpensive. Accordingly, the NPS Natural Sounds and Night Skies Division convened this Sustainable Outdoor Lighting Training Workshop to bring together national park managers, cultural resource experts, scientists, and experts in security and law enforcement with lighting manufacturers, designers, and engineers to share experiences and advance knowledge about the effects of light on national park resources and values. Participants also identified various ways to mitigate those effects while simultaneously stimulating industry, research and technology. Advances in lighting efficiency and controls, such as LEDs and adaptive technologies, hold great promise for helping NPS achieve its lighting objectives while protecting night skies and other national park resources from the unintended effects of light.

We would like to express our thanks to the participants in this training workshop. By sharing their expertise, they have increased our understanding and furthered the NPS goal of protecting naturally dark environments. As technologies change, NPS will continue to work with stakeholders to understand the effects of lighting on park resources and options for reducing those impacts to ensure the enjoyment of captivating views of starry night skies for generations to come.

Karen Treviño

*Chief, NPS Natural Sounds and Night Skies Division
Natural Resource Stewardship and Science*

About the National Park Service Natural Sounds and Night Skies Division

The Natural Sounds and Night Skies Division works to protect, maintain, and restore acoustical and dark night sky environments throughout the National Park System. We use 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.

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