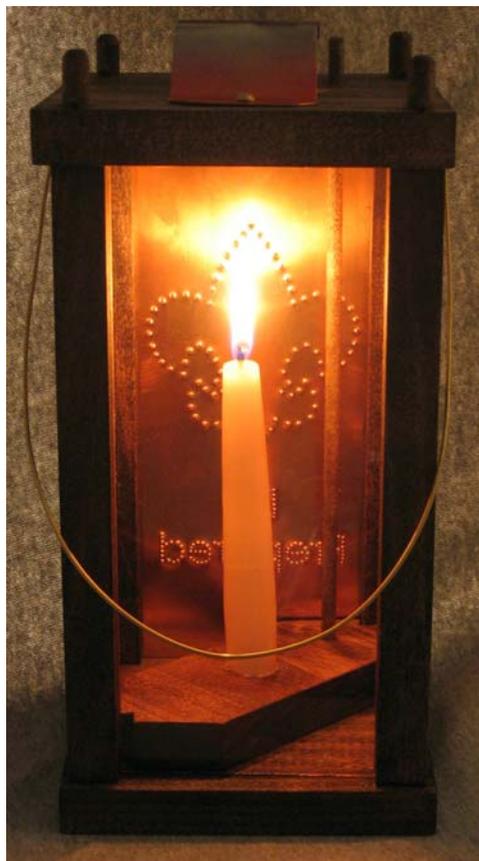


# Dark-Sky Camping

## Best Practices in Illumination for the Boy Scouts

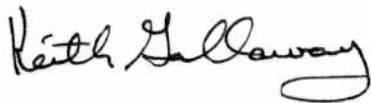
By Robert Wagner, Heart of America Council; Chad Moore, National Park Service; and Leo Smith, International Dark-Sky Association



If you have ever spent the night in the backcountry at Philmont Scout Ranch, you know the thrill of looking up at a brilliant, star-filled sky.

After a long day on the trail followed by a rousing campfire, there is nothing that connects you with God and nature like the beauty that a dark sky can reveal to us.

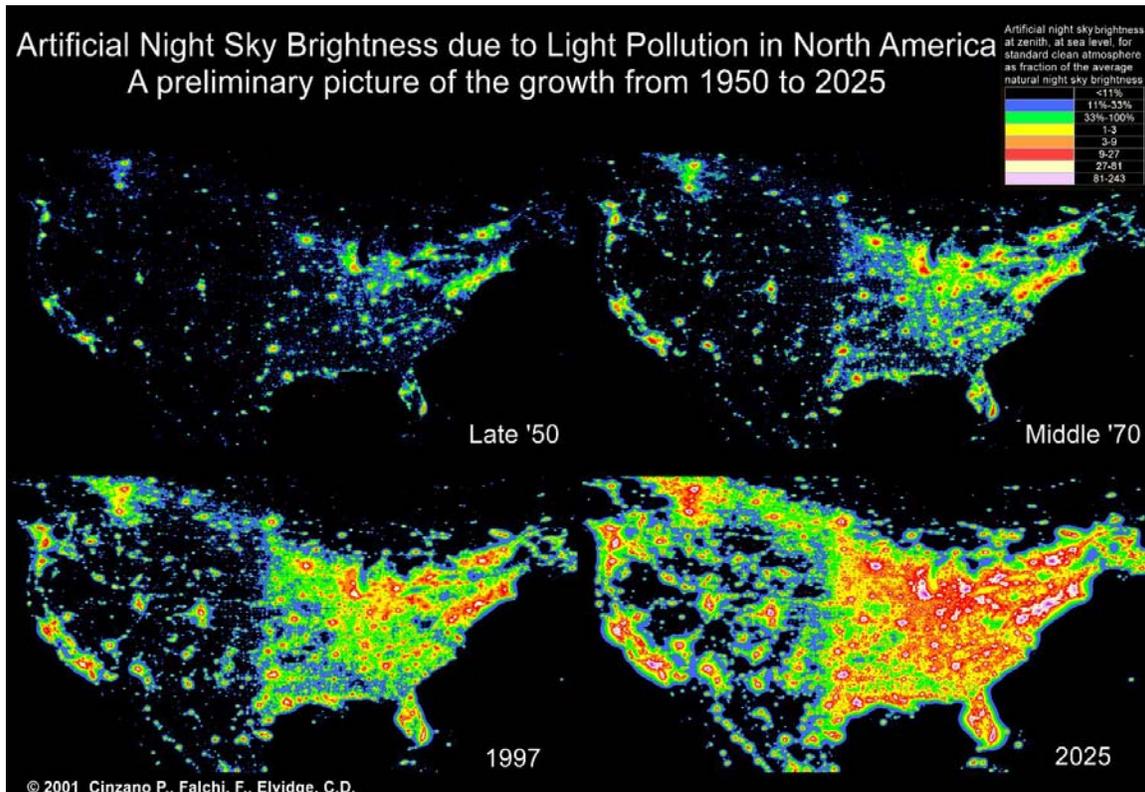
Robert Wagner, Chad Moore, and Leo Smith share with us a common-sense, practical document that reminds us all of the economic, esthetic, and life-enhancing virtues of maintaining a dark sky. The challenges presented to us are timely and deserve our immediate attention. To quote the authors, it is all about being able to “look up into the night and see the same sky that our grandfathers did”. What a great gift that would be to future generations.

A handwritten signature in black ink that reads "Keith Galloway". The signature is written in a cursive style with a large, sweeping loop at the end of the last name.

Boy Scouts of America  
National Director of High Adventure  
General Manager, Philmont Scout Ranch

## Introduction to Light Pollution

In 1879 the invention of the light bulb ushered in a new era to our cities and towns. Expensive and hazardous gas lighting could now be replaced with electrical lights to aid the nighttime traveler. Now, over 125 years later, we find ourselves with an over abundance of light shining into the night sky. Scientists for the National Park Service have estimated that as we approach the light bulb's 150<sup>th</sup> birthday, we have left ourselves with almost no dark skies remaining in the lower 48 states.



Light Pollution is the name coined for excess illumination. Light Pollution is mainly identified through Sky Glow, Light Trespass and Glare. Sky Glow can easily be seen as a bright haze hanging over our cities. The National Park Service has documented the sky glow from Las Vegas affecting parks some 200 miles away. Light Trespass is lights shining off of a property and onto a neighbor's property or street. Glare is probably the most recognizable and hazardous form of light pollution. Looking over on a cityscape, we see many bright points of light. These bright lights provide us with little useful light and impair our night vision. When faced with bright lights our pupils automatically contract to regulate the intensity of light entering the eye. Like entering a dark movie theater on a sunny day, dark objects are difficult to see.

Why should we be concerned with excess light? It is estimated that the United States wastes around one-billion dollars a year to light up the sky. This converts to around six million tons of coal. Burning six million tons of coal results in around 5.2 million tons of carbon dioxide going into the atmosphere for global warming. Other pollutants released during this process are Oxides of Nitrogen (smog), Sulphur Dioxide (haze), minute particulate matter (associated with lung ailments) and Volatile Organic Compounds.

Around 9.4 billion gallons of water will be evaporated to dissipate the heat generated in power plants.

Since the first plants and animals appeared on our planet, we have had sunlit days followed by dark nights. Every living creature has adapted to this cycle of light and dark. With the proliferation of nighttime lighting, we are finding that many forms of life, including humans, are negatively affected by the lack of darkness at night. Examples of these effects include our body's reduced ability to produce Melatonin, a cancer-fighting chemical and baby sea turtles crawling toward streetlights instead of the open ocean. Bright, glaring lights while we are driving or walking leads to impaired vision and accidents. Finally, we are all aware of the problem of lights shining into our eyes while we are trying to sleep. This leads to fatigue and stress. The International Dark-Sky Association has links to research papers detailing this and many other environmental issues surrounding nighttime lights.

### **The Balance Between the Need for Darkness and Light**

The human eye can adapt to a wide range of lighting conditions. This can range from bright sunny days to dark moonlit nights. The ability of our eyes to adapt is not instantaneous. Can you recall walking from a bright sunny day into a dark movie theater? How long did you have to stand by the door before you were able to see an open seat? One of the issues we will be looking at is an overall illumination strategy to avoid areas where a person can become visually impaired by moving between overly lit and too dark areas.

Nearly 70% of our children live in places where the Milky Way cannot be seen. A truly dark sky free from the effect of cities near and far is even rarer. Being able to sleep under the night sky, unaffected by light pollution, is rapidly becoming a once in a lifetime opportunity. It is important that we look at the exterior lighting we are providing and ensure it does not conflict with this opportunity. Leave No Trace camping teaches us to minimize our impact upon the world around us, Dark-Sky Camping will teach us how minimize our impact upon the night sky and our night vision.

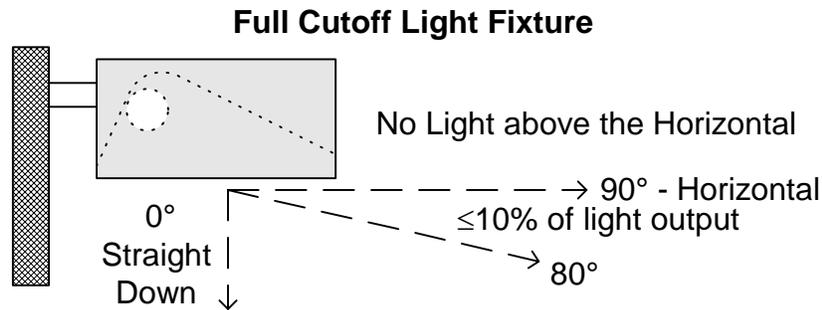
Having explained some reasons why darkness is a necessary part of the nighttime, it is important to identify places where light might be beneficial. As Scouts, we understand the principles of being prepared. A flashlight is an indispensable tool for finding your way around a dark tent or making your way back from a campfire. It is included in every checklist for Council and High Adventure Camps. During a severe storm it might be the only light available should the electricity fail. There are some places where permanent lighting can be deemed essential to safety. Places like a camp phone, latrine or Ranger Station might be considered for illumination should an emergency arise in the middle of the night. Stairs where people might trip may also need minimal lighting. It is important to understand the nighttime activities of your Scouts and identify the potential hazards they may encounter. Even when lighting is necessary, we can employ "best practices" to ensure that we don't affect the environment any more than necessary. Some events like an evening swim or basketball court can be identified for reduced lighting once the activity concludes. Many lights are just too bright, and could provide good illumination with only a small fraction of their current luminance. Take the time to inventory your

exterior lights and determine if they need to run continuously, be put on a timer, or replaced with a lower wattage bulb. Don't forget to examine interior lights that may shine out windows creating a problem.

### Various Laws and Regulations from Across the USA

It is important to know that many states, cities and government agencies might have laws restricting light pollution. This training is not intended to provide a legal summary of all of these regulations, but merely give the reader an idea of what could be regulated. We will demonstrate lighting practices that can coexist with dark-sky camping. Always ensure your lighting plan complies with existing laws and ordinances.

The New Mexico Night Sky Protection Act was introduced as a state law in 1999. It requires lights to be shielded so light is not directed into the sky. The restriction of directing light into the sky is very common in city ordinances. The Illumination Engineering Society of North America has a rating for fixtures of this type and calls them Full Cutoff or Fully Shielded. The Act also sets a lighting curfew of 11pm for outdoor facilities such as ballparks or amphitheaters and bans new mercury vapor fixtures. The EPA Act of 2005 bans the production or importing of Mercury Vapor ballasts after January 1, 2008. Madison, Wisconsin has prohibited lighting where the light source is visible from outside the property.



The Florida Fish and Wildlife Conservation Commission has established several new regulations for new coastal construction that affects Marine Turtles. This includes provisions for tinting all windows and glass doors on the seaward sides of dwellings. It also has limits for lights of 480 lumens (about 40 Watts) or less in heavily shielded light fixtures. This sort of minimalist lighting and shielding is what we will be looking at next.

## **Best Practices in lighting**

In reviewing the previous sections, it should be obvious that to provide a dark environment we need to minimize the light our eyes have to adapt to. The first step is to walk around your camp at night and inventory the light and glare you see. Take into account all lights regardless if they are currently on or off – like a cabin that might only see occasional use. Next, rank these lights based on their perceived affect upon your night vision. With a prioritized list, we can then proceed to identifying how to resolve each type of problem.

Let's look at the simplest solution for lights. Is the light really essential? Many times we provide light without a clear need for it and sometimes the light we do provide really doesn't solve the need. Removing unwanted and useless lights will provide allow us to focus on lights that are essential to the camp. When identifying lights that can be removed, we can also look at lights that can be turned off at certain times. Perhaps there is a trading post that closes at 9pm. Do all of the outside lights need to remain on all night? Establishing procedures for shutting off lights or installing timers to automatically turn off lights will help prevent an unintentional problem by a careless act.

By now you should be left with lights that you deem essential. These lights are also setup to be on only when necessary, using the minimum level of light sufficient for the intended purpose or identified for replacement. Now lets look how to provide lighting in a manner that minimizes its effect upon your night vision. When you start looking at light fixtures and bulbs you will see a variety of terms the lighting industry uses to identify how a fixture will perform. Some of the terms you will see are: Full Cutoff (aka Fully Shielded), Semicutoff, Cutoff, Dark Sky Friendly, IDA Approved, Lux and Lumens. Properly mounted fixtures labeled as Full Cutoff are ideal as they allow no light above upward into the sky and very little light laterally where it will cause glare. Some fixtures, especially lower cost ones, will not have such a certification. Fixtures labeled Fully Shielded, Night Sky Friendly, or IDA Approved are superior to most others and are probably adequate to protect night skies. Fixtures labeled Cutoff are inferior to Full Cutoff; Semicutoff and Unshielded fixtures should clearly be avoided. Lux is the measure of light upon a surface, while Lumens is the measure of the amount of light a light bulb puts out. You can find more detailed and technical definitions from Illumination Engineering Society of North America (IESNA).

There are also several different technologies for providing light. In our household, we typically use incandescent lights. Only about 10 percent of the energy goes to producing light. Mercury Vapor lights are about twice as efficient as incandescent. Since the EPA Act of 2005 bans importing or production of mercury vapor ballasts starting in 2008, these should be avoided. Much more efficient technologies that exist include Metal Halide, Sodium, and Fluorescent. Fluorescent lights are many times more efficient that incandescent. Finally, LED lights are probably the most efficient on the market today. Determining which technology you use will vary as many are not available for low light situations.

The light fixtures that we want to use have shields to prevent the light source from being seen at a distance and are much dimmer than your standard commercial light. Lets take an example and see how this can be accomplished:

We have a 24-hour emergency office needing light so our visitors can identify where to come in case of a nighttime emergency. In general we might put a carriage light or spotlight to identify the building. Both of these methods typically have a lot of glare and really hurt our night vision. A better option might be to recess a light under the eave of the building so the light source is hidden from view. There are some other choices to consider as well. If we are replacing an existing troublesome light, then consider a cylinder/can style fixture that can be installed in the same location. Finally, look at an internally illuminated sign. A sign with light colored letters and dark background will require less light to see at a distance than a sign with light background and dark letters. Consider the ability to adjust or dim a light once installed. With some testing, you might find that a fixture installed with 40watt incandescent lights works just fine with 20watt or lower light bulbs. When looking at replacing incandescent lights with fluorescent lights, try to find ones with the same lumen rating (produces the same amount of light) or less. Other areas like parking lots or entrance roads may use sodium lights for low glare and less visual interference.

With our emergency building identified, we want to look at a set of stairs that people keep tripping on. Like the building, we could install a light under the eave, but because the eave is two stories high, this would still cause problems. The brightness of light you will need to provide is based on the distance between the object you are lighting and the source. We can use a bright light far away or a dimmer one close up. We could solve this problem with low level shielded step lighting mounted in a vertical riser, or a small light hidden under the handrail or otherwise hidden from view.

These recommendations will solve many sky glow and glare problems. Perhaps now you are looking around your camp and finding that many interior lights are creating an exterior problem. The amount light coming from the emergency building windows far exceeds the new fixture we installed. Earlier we mentioned the Florida Fish and Wildlife Conservation Commission requirements for tinting windows. This requires windows to be tinted to a transmittance value (light transmission from the inside to the outside) of 45% or less through the use of tinted glass, window film or screens. Effectively reducing the amount of light going outside will keep interior lights from becoming a nuisance.

When looking at camp activities, you may find some that require a lot of illumination. This might include a night swim at the pool or an evening basketball tournament. Outdoor sports require light to be able to safely judge things like distance and color. Many people illuminate these activities with bright floodlights typically aimed at a high angle. These create glare that can be seen for miles and impairs your night vision. We need to identify shielded light fixtures that illuminate only the appropriate area, and keep the light source from being seen offsite. Many of these types of lights cannot be dimmed so it is imperative that the lighting system is designed correctly from the start. Lighting of this nature should be designed by a competent architectural lighting designer familiar with low impact illumination. Some aspects that we expect to see in the plan are an average illumination and a diagram showing shielded fixtures and their placement.

The final aspect to a lighting review is the type of portable lights allowed into the campsites. This can range from military style red lights visible only a short distance away to a handheld headlamp capable of providing light visible for miles. Consideration should be given for light shielding and perhaps a curfew for unshielded lights. Educating your visitors about light pollution and the impacts of bright lights will help ensure everyone can enjoy the stars and have a peaceful night's sleep.

### **Best Practices in lighting - Review**

Putting some thought into lighting can provide better safety and illumination, reduce our environmental impact, and reduce energy costs. Doing the best we can in small but significant ways is often called "best management practices."

The purpose of these BMPs are to:

- Insure "good neighbor lighting" by minimizing light trespass
- Improve visibility and safety at night
- Preserve the dark night sky for astronomy and enjoyment of the starry sky
- Allow nocturnal animals to have appropriate habitat and a natural environment
- Conserve energy and resources and thereby saving money
- Minimize suspected health risks to humans from adverse exposure to light at night

### **Permanent lighting**

- **Use light only when and where it is needed.** Don't install outdoor lights just because you can; make sure it is really necessary. If a light is needed only part of the time, consider using switches or motion sensors. Don't leave a light on all night - you wouldn't do it inside your house, why would you do it outside?
- **Use the right amount of light, not too much, not too little.** In darker areas you often need less light to be able to see. Avoid installations that are too bright in one area while dark in another area.
- **Point lights down at the ground, and use shielded lights.** Lights that throw light sideways - floodlights, wallpack lights, and unshielded bare bulbs, create more glare than usable light. This reduces visibility while greatly impacting the nighttime scenery and ecological impact. Pointing lights at the ground and using shielding so that no light escapes upward or sideways above the horizontal can easily fix these problems. Many lights are now available with shielding or "full cutoff" design, and many more can be retrofitted.
- **Use energy efficient bulbs.** Incandescent bulbs, the "common" light bulb, are very inefficient. A much better choice is compact fluorescent bulbs. These use 1/5 the energy to produce the same amount of light, and are now available in models that work in extreme cold. Also avoid mercury vapor lights, as they are inefficient and create hazardous waste; use a sodium light in lieu of a mercury vapor one.

### **Portable lighting**

- **Allow for dark hours.** One bright lantern can erase the night for several hundred feet in all directions. When camping, set a time that lanterns will be

turned off, so that others may enjoy the starry sky and nocturnal animals can have the proper habitat.

- **Use flashlights.** A small flashlight is ideal for getting around at night- it provides light when and where you need it, in the right amount. To preserve your night vision, use a red filtered flashlight or red LED flashlight, you will be able to see much better once you turn your light off.

If everyone were to think carefully about the outdoor lighting they install or switch on, we could restore the night to its natural splendor in many areas. Billions of dollars would be saved each year in electrical costs, streets and towns would be safer, nocturnal animals would have habitat unspoiled by stray lights, and we could look up into the night and see the same sky that our grandfathers did. It is about being courteous, thrifty and fulfilling our duty to our environment and fellow citizens.

## Sample Light Installation - Doorway

We are now going to demonstrate a simple conversion from a light fixture that produces a lot of glare to one that is better suited for dark sky camping. In the example we have an existing carriage style incandescent light. It uses a 60W light bulb with no shielding on the front or sides. Most of the light it produces is directed horizontally and results in glare.



*Left – Previous Light Fixture*



*Right – Replacement Light Fixture*

In selecting a replacement, we decided that we wanted to use the existing 120v hookup and just replace the fixture. The fixture had to be rated for outdoor use, have the ability to use a lower wattage light bulb, and block glare from the eyes of people approaching the door. We choose the SiteLight™, Bronze Post Sconce Light from Red Dot – Model K851BR. This was available online only and was shipped and purchased for less than 20\$, well within our budget.

This fixture uses light bulbs with a candelabra base allowing us a selection of bulbs 10 watts and below. Our fully adapted night vision is able to see a single candle many miles away. While this doesn't sound very bright, it will provide plenty of light to the adapted night eye. After replacing the light, we try a couple of different light bulbs to see which one produces the best results.

First we demonstrate the fixture without the light shield to show that even low wattage bulbs can produce glare that effects our night vision.

After installing the shield, we can see the light is no longer in our eyes, but aimed down on the ground.



*Left – 7Watt light bulb without shielding*



*Right – 7W light bulb with shielding*



*Above – Final Installation with 4Watt Light Bulb*

Finally, we try different light bulbs to see which one produces the best results at the lowest wattage. You might even consider looking at red colored light bulbs for the least negative impact upon the eyes. The electrical savings for going from a 60W light bulb illuminate all night long to a 4W light bulb is around \$24/year.

In keeping with our dark sky policy. The effective light appears much closer to that of a full moonlight night than the original fixture.

## Sample Light Installation – Stairs

We currently have a flight of stair illuminated with a floodlight. Because the floodlight is extremely bright and can be seen for some distance, we have identified it for replacement.

In this location, we are looking at installing several other fixtures so we have decided to use low voltage landscape lights. Landscape lights have a higher initial cost for the transformer, but individual lights are fairly inexpensive. Our transformer select – 100 Watts, allows us to connect several fixtures as long as their total wattage doesn't exceed to transformer's rating. Additionally, this system allows for the use of motion and photo sensors to minimize our lighting even further.

We purchased a 100Watt Malibu™ Transformer, 2 - LT8 Round Surface Lights, wire and two red replacement bulbs.



*Left – Parts purchased for installation*



*Right – Previous Light Fixture*

We start by mocking up the installation. This involves hooking up the wires and lighting the fixtures. We can tape the fixtures where we want them to see if light is being placed where we want it and at the appropriate levels.



*Left – Lights taped into position*



*Right – Stairs at night with 7Watt Lights*

After trying several different fixtures and locations, we decided upon the best location that meets our needs.

The final position is marked and the lights are installed.

After installing the lights, we try a couple of different light bulbs to identify what is the lowest level of illumination we can use. The 7Watt bulbs produced a very sharp contrast between light and dark areas. After switching to 4W red bulbs, this contrast was diminished and our night vision restored.



*Right – Stairs with 4Watt Red Lights*

When replacing fixtures or working with electricity, always follow the manufacturer's guidelines and local electrical codes.

### **Illuminating Roads, Parking Lots and other hazards**

Many of us are used to having our streets and parking lots illuminated. It should be noted that our vehicle's headlights are capable of good illumination up to speeds of around 35MPH. Above this speed, our reaction time and speed typically prevents us from stopping before hitting objects in our headlights. Cities get around this problem by providing streetlights. One of the problems with streetlights is the encourage people to walk around without flashlights, thus making them less visible. Higher speeds also make it more difficult to stop should something move into the path of you vehicle. A safer alternative is to not provide streetlights and reduce vehicle speed to manageable levels.

Parking lot lighting is typically provided for convenience of customers. In a Dark-Sky camp with Scouts, this is not necessary and will be difficult to shield. Contact the manufacturer of any existing lights to see if shields are available.

Many times we use light to identify hazards. It is important to remember that some visitors to our camps may be visually impaired and using lights may not prevent them from injuring themselves. A better solution is to prevent the person from wandering into or near the hazard. Physical barriers such as fences are better suited for preventing this kind of accident than a floodlight.

## Conclusion

By making good decisions about our lighting preferences, we can provide task lighting and an opportunity to experience an unobstructed night sky. It is important to understand how our camps look at night as well as the day. When providing general illumination, shoot for the moon! The amount of light provided by the full moon is around .1 lux (.01 Foot Candles). A candle at a distance of 1 foot produces around 10 lux. Our candle would need to be mounted about 10 feet away from the ground to produce moonlight.

By moving toward dark-sky camping you can ensure Scouts and Scouters will have the opportunity to view the stars unimpeded by careless lighting.



## **Acknowledgements and Further Information**

Light Pollution Forecast for USA - Credit: P. Cinzano, F. Falchi (University of Padova), C. D. Elvidge (NOAA National Geophysical Data Center, Boulder).  
Copyright Istituto di Scienza e Tecnologia dell'Inquinamento Luminoso (Light Pollution Science and Technology Institute) of Thiene, Italy,  
www.istil.it . Additional Information - <http://www.lightpollution.it/dmsp/>

Some data are published in Monthly Notices of the Royal Astronomical Society, vol. 318, pp. 641-657 and in Light Pollution: The Global View, ed. H.E. Schwarz, Astrophysics and Space Science Library Vol. 284, Kluwer, 2003., pp.39-48.

IDA – International Dark-Sky Association, Tucson, Arizona [www.darksky.org](http://www.darksky.org)

National Park Service Night Sky Team - <http://www2.nature.nps.gov/air/lightscapes/>