Summary of guidelines for outdoor lighting used in natural areas (low-impact lighting)

Over the past 15 years there has been mounting evidence that artificial light at night (ALAN) fundamentally changes the environment and undermines the ecological integrity of plant and animal habitats. The most obvious effect of ALAN is the urban sky glow that is visible at great distances from cities. Not only does this form of light pollution reduce the visibility of a star-filled sky, but it also affects the survival of wildlife.

The Royal Astronomical Society of Canada, in cooperation with Parks Canada, developed guidelines for outdoor lighting (GOL). These Guidelines (www.rasc.ca/dark-sky-site-guidelines) were based on an extensive assessment of the biological and behavioural sensitivities to artificial light at night (ALAN) and practical limits on lighting for human vision. The Guidelines were developed independently from the lighting practices recommended by the lighting industry, which are generally used in large urban areas. The GOL forms the basis of the Canadian Dark Sky Preserve Program, lighting within Parks Canada facilities, and in Dark Sky Places recognized by the International Dark-Sky Association.

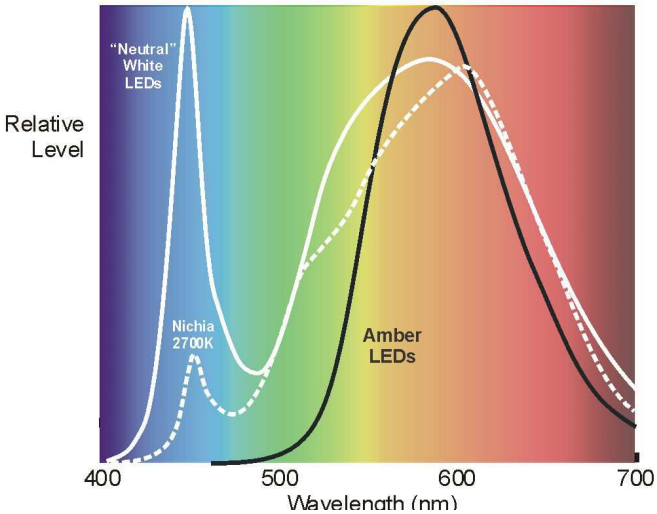
The guiding principle behind the GOL is that there be no artificial light at night. However if the manager deems it necessary, then any lighting must comply with these Guidelines. The GOL is based on the principles of "low-impact illumination" and addresses four characteristics of light:

1. Spectrum (colour),
2. Brightness (illuminance),
3. Extent (shielding), and
4. Duration (timing)

Moonlight is the only significant source light at night. However, it affects wildlife survival only during the few days around the Full Moon. ALAN is generally much brighter than the full Moon, so its impact should be strictly limited by controlling the four above attributes.

1. Spectrum

The lighting industry refers to the "colour of light" by its similarity to the apparent colour of a hot surface, called its Correlated Colour Temperature (CCT), which is usually expressed in degrees Kelvin. However, the CCT is not representative of the biological and vision impact of the light. The impact of light on ecology and human vision is best assessed by the wavelength distribution of light, i.e. its spectrum.



DSP-compliant amber-light spectrum compared to non-compliant white-light spectra.

White-light emissions generally have a CCT of 3000K or higher and contain more than 10% blue spectral components. This is not compliant with the GOL without additional restrictions on brightness and shielding.

The spectrum of the emitted light should have minimal emission (<1% of the total emitted light) shorter than 500 nm (roughly green in the visible light spectrum). This is an effective and practical limit based on:

a) increasing use of phosphor converted LEDs (PC-LEDs),
b) relatively high efficacy (lumens/watt) of PC-LEDs,
c) low sensitivity of human vision to wavelengths shorter than 500 nm, and
d) high sensitivity and good visual acuity of human vision for wavelengths longer than 500 nm.

2. Brightness

Only humans use artificial light. Since ALAN is disruptive to animal biology and behaviour, its brightness must be restricted to low practical values. These values are based on what is needed for specific human activities.

Light enhances human navigation. For pedestrians, this includes situational awareness and the ability to read a map, which may include colour-coded symbols. These are satisfied with illumination levels of 1-lux (equivalent to about 10X the light of the full Moon) using broadband amber spectrum (500 nm to 650 nm).

In situations with pedestrians and motor vehicles in close proximity, 3-lux is sufficient. These levels may be used along roadways and in large parking lots. At more than 3-lux night vision becomes compromised and recovery of dark-adapted vision after high-level exposures becomes longer. A good indication of the brightness limit is when the colour of the amber light becomes less saturated and resembles candlelight.

3. Extent

Since ALAN is disruptive to the natural environment, so the contaminated area must be strictly limited with adequate shielding. Insufficient shielding creates glare that reduces visibility and produces light trespass beyond the target area. Minimizing these effects is a high priority.

When a large area is to be illuminated, Full Cut-Off shielding may be sufficient. However, even these fixtures emit 10% of their total light in the "glare zone", which is between horizontal and 10 degrees below the horizontal. This light contaminates the area out to almost a hundred meters.

For smaller illuminated areas, Sharp Cut-Off (Sh-CO) shielding should be used. This allows less than 1% emission in the glare zone, and thus produces negligible glare beyond the target area.

Shielding is adequate when the luminaire is almost invisible from beyond the illuminated target area. The extent of the illumination is easily expressed in terms of the mounting height of the luminaire. A single Sh-CO luminaire will illuminate out to a distance of 3x the mounting height from the fixture.

4. Timing

ALAN should be used only when people are active in the area. In most campgrounds, scheduled activity ends within two hours after sunset, at which time all non-critical lighting should be turned off. Some ALAN may be authorized to permit way-finding after dark, though this illumination should be no brighter than 1-lux.

Validation

Luminaires compliant to these guidelines have been demonstrated in several communities and protected area agencies such as Parks Canada and the US National Park Service. When the need to minimize the ecological impact was explained, visitors readily understood and accepted the need for these lighting restrictions.

Low-impact lighting typically uses less than one quarter of the power used by typical LED luminaires, and the Milky Way remains visible as long as the observer is not standing in the illuminated area. For visitors accustomed to using their night vision, illumination levels of less than half the GOL levels were satisfactory and result in additional savings in electricity use.

Low-impact lighting is used along an unpaved rural road (left). The amber spectrum helps preserve night vision, and sharp cut-off shielding minimizes glare and light trespass off the right-of-way. These images show the results for a 3-meter mounting height and 20 meter spacing.

Glare along a rural road obscures our view of two deer. The glare reduces visibility into the less-illuminated areas and draws our attention away from the real hazards. Can you see the second deer beyond the lights in the centre?

References:

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Websites:

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