



The Ecological Cost of Artificial Light

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Public lighting must be reimagined so it's both functional and safe, has less impact on ecological systems and allows visibility of the stars again.

In 2016 it was estimated that around 80% of humanity and 23% of the land mass is affected by artificial light at night (ALAN). While light pollution is generally not considered as serious as other anthropogenic pollutants, the environmental impacts of ALAN are just as important as air, water and soil contamination.

Comprehensive standards and ordinances for lighting are crucial because ALAN has a negative impact on most living organisms, whose biological rhythms and processes are fundamentally linked to the presence, intensity and spectrum of natural light. “Life has evolved

on Earth with light days and dark nights, but now that's changed there's concern about the consequences,” says Dr Chris Kyba of the German Research Centre for Geosciences in an interview. The increasing use of energy-efficient, high-intensity white LED lighting technology in the past decade is significantly compounding matters.

One reason white LEDs are problematic is that they emit broad range light. The broader the spectrum of artificial light, the broader the group of organisms that are affected by it. “Because light is never neutral, it impacts organisms in different ways,” explains Dr Sibylle Schroer of the

Leibniz Institute of Freshwater Ecology and Inland Fisheries (<https://bit.ly/2RKnFrO>). “With a very broad spectrum, you will hit all of them.”

In addition to numerous adverse biological effects, altered behavioural patterns – such as foraging, courtship, mating, navigation and migration – as well as predator/prey and plant/pollinator relationships can vastly alter biodiversity, ecosystems, crop yields and food production. Change, weaken or break just one thread in the web of life and the repercussions can be dire.

Dr Andre Chiaradia of Phillip Island Nature Parks is familiar with how ALAN

from ecotourism activities impacts prey/predator relationships. In Australia and New Zealand each year, hundreds of thousands of visitors view little penguins at night in their natural colonies, but this activity requires artificial lighting. Thanks to Chiaradia's research, conservation areas are now using dim lighting with a spectrum that has the least impact on penguins, while reducing light pollution and improving traffic management to mitigate light-induced mortality of shearwaters. "It's vital to preserve the integrity of the natural skylight and keep precious island arks like Phillip Island, home to the world's largest colonies of little penguins and short-tailed shearwaters, in the dark," he told the Riding the Lightwave of Technology conference at the Siding Spring Observatory last September.

Marine turtle ecologist Dr Karen Arthur of the University of Hawaii at Manoa supports this approach. "Artificial light at night can impact a wide array of migratory species," she said at the Siding Spring conference. "As early as 1911 it was known ALAN disturbed marine turtles, disrupting critical behaviours including adult nesting and hatchling orientation, sea finding and dispersal. Seabirds can also be disoriented, and fledglings can be grounded where they're vulnerable to multiple threats or they might starve to death. For these reasons and more, it's crucial we consider sensitive environmental receivers and that the impacts of light are abated."

While LED technology has allowed us to use light cheaply and apply it profusely, such energy-efficient light happens to be brighter, more light-polluting and harmful than the light it generally replaces, causing a host of dilemmas.

"Essentially, what we're doing with light is similar to deforestation," says Dr Therésa Jones of The University of Melbourne in an interview. "We're creating an artificial environment with barriers that fragment habitats animals have to negotiate. These fragmenting

Artificial light disrupts critical turtle behaviours, including adult nesting and hatchling orientation, sea finding and dispersal. Credit: Wexor Tmg



barriers are even more detrimental when they consist of ecologically disruptive, high-intensity, blue-rich light – the kind emitted by energy-efficient white LEDs. Living organisms have nothing in their genetic make-up to cope with the degree of exposure to this type of challenge."

ALAN is also disrupting insects. A 2017 study in *PLoS One* (<https://goo.gl/ZDoFVH>) linked light pollution to a 75% decrease in flying insects over the past 30 years. This alarming loss not only reduces biodiversity, but food production

depends upon healthy insect communities for pollination, natural pest control, nutrient cycling and the structural integrity and fecundity of soil. This means far more care needs to be taken with aquatic areas because artificial lighting near waterways draws insects up from the water's surface towards lighting sources, which disrupts food chains and weakens the ecosystem.

In the documentary *Brilliant Darkness: Hotaru in the Night*, retired University of Florida entomology professor



Little penguins are a popular tourist attraction, but this requires artificial light. JJ Harrison CC BY-SA 3.0



James Lloyd equates the disappearance of fireflies to a “canary in a coalmine” because these insects are bioindicators of the health of the environment. Researchers that investigated various intensities and wavelengths of LED lighting on firefly courtship activity argued that “spectral emission, the directionality of light sources (street lighting luminaires versus luminaires for paths) and distinction between point sources and larger sources of diffused light be given greater consideration when installing artificial lights around firefly habitats”. This advice is also applicable to other species.

Wild plants are adversely affected by ALAN too. Trees exposed to light pollution bud out of season, which then impacts insects that depend on the timing of budburst for their survival. Early budding can also leave trees susceptible to cold weather damage. This could leave crops and fruit orchards vulnerable as well.

“Lighting technology has been developed for optimum use by mankind,” lighting designer Dr Tim Shotbolt said at Siding Spring. “However, biota perceives and uses light, and also responds to the absence of visible light, sometimes quite differently to humans. We understand this in a limited and vague manner due to a lack of detailed, reproduceable scientifically verifiable research. Furthermore, the potential impact of artificial light on the greatest life mass on Earth, prokaryotes, is even less well understood.”

We are also constrained by current lighting metrics. “Commercial lighting models are based on photometry for humans, and do not account for light visible to wildlife,” said Dr Kellie Pendoley of Pendoley Environmental Ltd at Siding Spring. “Although LED lighting is being developed with less blue wavelengths in response to concerns for endangered species, there is no such thing, for instance, as ‘turtle-friendly’ lighting. The Commonwealth Department of Environment and Energy, in association with Pendoley Environmental, is forming light pollution guidelines for marine turtles, seabirds and migratory shorebirds, but far more action is needed globally.”

Light pollution doesn’t have to be blatantly obvious. According to a 2018 news feature in *Nature* (<https://goo.gl/AZ3TcQ>), skyglow “can be so faint that humans can’t see it, but researchers say it could still threaten the 30% of vertebrates and 60% of invertebrates that are nocturnal and are exquisitely sensitive to light”.

Dr Barry Clark, Director of Outdoor Lighting Improvement for the Astronomical Society of Victoria, told the Siding Spring conference that illumination must be as benign as possible, especially in urban environments. “The human health and ecology cases for using minimal light at night that are blue-poor are so strong, all outdoor luminaires, outdoor advertising etc. should be limited to about 2200 K or less,” he said.

Jones says “it’s vital we make a place for the nocturnal realm. Our urban spaces need more dark refuges. Constant lighting is unnecessary and wasteful. We could be using sentient illumination that responds to foot traffic and turns off when not needed. It’s critical we take immediate action to minimise lighting at night.”

Adam Carey, Director of Standards and Advocacy for the Illuminating Engineering Society of Australia and New Zealand, believes public lighting can be reimagined so it’s both functional and safe, has less impact on the environment and can allow visibility of the stars again. “This involves a radical rethink on how cities plan their public lighting infrastructure and address the creep of lighting,” he said at Siding Spring.

While some urban spaces are benefiting from best practices, we’re falling down in a big way with street lighting. Throughout the world there are failed LED retrofits due to the inherent drawbacks of the technology, a lack of awareness on how to mitigate them, poor LED design, improper installation, outmoded standards that fail to address and counter these problems, plus the use of insufficient lighting metrics that cannot accurately measure the parameters needed to provide proper guidance for the application of LED lighting.

Amateur astronomer Peter Allison notes that a 2-year LED streetlighting trial in Brisbane met national lighting standards yet resulted in unfavourable amenity outcomes for city residents and their neighbourhood. “Designing to comply with illuminance requirements should be just one small objective,” he said at Siding Spring. “There’s much more involved than the luminaire selection, installation and trial procedures.”

Although urban residents in an urban environment need to feel safe, comfortable and secure at night, bright light is not the answer. While it may provide the illusion of safety, such lighting actually

impairs visibility, compromises safety (because strong contrast reduces the ability to detect threats or hazards in shadows), hinders navigation, prevents dark adaptation (so it takes time to adjust to different lighting levels) and also reduces visual comfort.

“There is no linear correlation between lighting and crime,” explained Mike Chapman, founding member of the Sydney Outdoor Lighting Improvement Society, at the Siding Spring conference. “It’s a contentious issue, but we need to understand there are many factors involved. Moreover, there’s compelling evidence that reduced or zero street lighting at night does not lead to increases in crime or road accidents. The use of appropriate lamps at night in fully shielded or fully cut-off outdoor luminaires should reduce ill-health, reduce artificial skyglow and greenhouse gas emissions, and even reduce crime slightly.”

Clark agrees. “Crime is a social problem, not a lighting problem. What’s more, some experiments with controlled conditions and careful counterbalancing have shown a positive effect of lighting in reducing road accidents at night, but subsequent investigations have indicated most of this research has been funded by the lighting industry. In practice, it seems any safety advantage initially conferred by lighting or extra lighting is soon lost because drivers tend to drive faster.”

Clark says that existing Australian standards for outdoor lighting and their draft revisions are failing to provide safe and appropriate illumination. “There may be a case for minimal blue-poor lighting to be provided for wayfinding and avoidance of pedestrian obstacles. Otherwise, extensive trials have shown overwhelmingly that dimming, reducing the numbers of operating streetlights or completely switching off all streetlights after a curfew does not reduce actual crime or reduce road accidents.”

Improving our awareness about what constitutes quality light and knowing how



Nocturnal creatures like bats depend upon darkness at night to thrive. Credit: Nikolas Noonan

to light responsibly can make all the difference in the illumination of urban spaces. Ideally, lighting should be aesthetically appealing, warm and welcoming, soft, indirect, evenly dispersed, thoughtfully positioned, pleasant to be around and have minimal blue wavelength content.

Unfortunately, we’re seeing the exact opposite with the dramatic rise in large media facades as well as bright, colourful, dynamic, synchronised lighting of landmarks, buildings and bridges with little thought given to its impact. When we take into account the biological, ecological and environmental costs of this practice, lighting for entertainment and visual appeal becomes untenable.

“ALAN needs to be formally recognised as a pollutant and regulated under state and Commonwealth environmental regulations,” Pendoley argues. “Engineering standards and legislation need to recognise upper limits on ALAN. Standard methods and units for measuring ALAN are required. Because environmental impacts and management of ALAN on wildlife cannot be regulated by a one-size-fits-all standards approach, the ecological impacts of ALAN should be risk-assessed and managed on a case-by-case basis.”

Simply put, our use of light must be optimised while minimising its impact. Herein lies an opportunity to apply a

framework that goes beyond reducing the negative effects of lighting to actually promoting the value of darkness and the benefits of a lack of light. If we better understand why we should protect and preserve darkness in urban spaces, designers, urban planners and policy-makers can be better informed to make value-sensitive decisions about night-time lighting in cities and towns. Improved appreciation for darkness will help establish desirable lighting infrastructure that can guide how modern nightscapes are lit. New possibilities exist if we design for darkness rather than just to reduce light pollution.

It’s clear that key research questions must be answered and knowledge gaps filled. Different disciplines also need to be connected so that research into the impacts of ALAN is co-ordinated and insights developed to better understand the challenges and complexities involved. It’s also imperative that firmer links are made between research, policy and practice.

Responsible lighting involves using the right kind of light and the right amount of light in the right way and at the right time. Underlying all of this is the knowledge that lighting the night to look like day has harmful consequences, and a less-is-more approach is best.

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