

LIGHT POLLUTION AND THE IMPACTS ON BIODIVERSITY, SPECIES AND THEIR HABITATS

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What is ecological light pollution?

Longcore and Rich describe artificial light that alters the natural patterns of light and dark in ecosystems as “ecological light pollution”.⁷

Ecological light pollution comprises direct glare, chronically increased illumination and temporary, unexpected fluctuations in lighting. The sources of ecological light pollution are very various and found in nearly every ecosystem in the form of “sky glow, illuminated buildings and towers, streetlights, fishing boats, security lights, lights on vehicles, flares on offshore oil platforms, and even lights on undersea research vessels”.⁷

Impacts of light pollution

Because the study of light pollution is still in its early days the impacts of this problem are not fully understood. While the increased brightness of the night sky is the most familiar of the many effects of light pollution (it is the most obvious and astronomers recognized it many years ago) many other alarming aspects are still unexplored: for example, the fact that light pollution leads to a great wastage of energy. On a global scale, approximately 19% of all electricity used produces light at night.¹⁸ The by-product of electric illumination generated by the burning of fossil fuels, is the discharge of greenhouse gases. These gases are responsible for global warming and the exhaustion of non-renewable resources.

Light pollution produces many other impacts on the environment. Harmful effects involve the animal kingdom, the vegetable kingdom and mankind. While light pollution is eminently detrimental to nocturnal and migratory animals and to animals in flight, it also produces harmful effects on plants.

IMPACTS ON PLANTS

Plants use darkness in many different ways. The management of their metabolism, their development and their life programmes are affected. Plants measure and react to night length which means the duration of darkness. For this reason short-day plants require long nights. If such a plant is illuminated



Figure 1. © Merlin D. Tuttle, Bat Conservation International, Inc.

temporarily during a long night, it reacts and interprets as if it had experienced two short nights, instead of one long night with a disruption. As a consequence its flowering and developmental patterns possibly will be entirely disrupted: short-day plants normally bloom in the autumn when the day length shortens. They utilise the long nights to start the onset of flowering; and subsequently, as the nights lengthen, the onset of dormancy, which enables them to resist the harshness of winter.¹

Trees provide entire ecosystems to numerous animal species. They are harmfully affected by light pollution. Trees have to adjust to seasonal alterations, and artificial light hinders them from doing so: various trees are kept from losing their leaves by light pollution. This has a consequence on the animals that depend on trees as their habitat. For instance, birds are prevented from nesting in trees as a result of the surrounding light pollution.

IMPACTS ON ANIMALS

Life has emerged with natural patterns of light and dark, so disturbance of those patterns influences numerous aspects of animal behaviour.⁷ Light pollution can confound animal navigation, change competitive interactions, alter predator-prey relations, and affect animal physiology.

Threats to birds

The effect of light in the form of fire or lamps attracting migratory and non-migratory birds at night, especially when foggy or cloudy, has been known since the 19th century and was and still is used as a form of hunting⁷. The reasons for disorientation of birds through artificial night lighting are not well known. Experts suggest that the navigation of birds using the horizon as orientation for the direction is disrupted by lighting and sky glow¹².

Lighthouses

The attraction of lighthouses and ships for birds was first recorded since the first operation in the mid 19th century and was the basis of the first detailed records of bird migration.

The number of casualties depends on the location of the lighthouses and was higher on the migration routes on the East Coast of the USA. Early surveys on the coast of British Columbia recorded an annual mortality of over 6,000 birds at 45 lighthouses.



Figure 2. Doñana, World Heritage site. © José María Pérez de Ayala.

The fatalities at lighthouses depend on the type of signal used. Fixed white lights attract more individuals than flashing or coloured lights⁵.

Light beams / Ceilometers

The attraction of light beams has been observed since the 1940s when meteorologists installed ceilometers - light beams - to measure the cloud height



Figure 3. Source: Gabinete Paralelo. "Consejo para el Proyecto Argentino" Foundation.

especially at airports. In 1999 Bruderer et al. studied the behaviour of birds exposed to a light beam and an X-Band radar. The light beam caused a change in the flight direction up to 15° and a decrease of velocity up to 3m /sec. Approximately 50,000 migratory birds (largest kill ever recorded at a ceilometer) died on October 6-8, 1954 at Warner Robins Air Force Base in Georgia, when a cold front moved over the Southeast⁷.

Filtering the longer wavelength of the lamps used and changing the units from a fixed beam into a rotating one, significantly reduced the number of casualties¹².

Offshore oil / Gas platforms / Light induced fisheries

Due to the fact that oceans have less artificial light sources compared to terrestrial environments, the effect and range of single artificial lighting is much higher. As a consequence of these circumstances marine birds are highly attracted by these sources. The birds are attracted by the flares of the platforms and can be directly injured or killed by heat, collision and oil; but also indirectly by the trapping effect of the light that leads birds to circle around the light source reducing their energy reserves and making them unable to reach the next shore or decreasing their ability to survive the winter or reproduce. Light induced fisheries use their light to attract fishes and squids but also have an effect on birds. Hooks then can injure these birds¹².

City lights / Horizon glow

The permanent growth of cities and the associated increase in artificial lighting by streetlamps and illuminated buildings has fatal consequences for migratory birds. These mostly nocturnal migratory species are disorientated and attracted by the sky glow which cities produce during the night. This effect arises especially under foggy and rainy weather conditions, with the result that hundreds and even thousands can be injured or killed in one night at one building.

The Fatal Light Awareness Program in Toronto, Canada has recorded data of collisions of birds with man-made structures for over 10 years. They recorded about 160 species of birds as victims of collisions. According to Daniel Klem Jr., biologist at Muhlenberg College in Pennsylvania, more than 100 million birds are affected by collisions

each year in North America and many of the species involved are recognised as endangered species.²⁰

To decrease the number of cases several cities (Toronto, Chicago, New York) started “Light Out Programs” to reduce the effect of sky glow and to protect migrating birds.

Towers

The growing number and height of telecommunication and broadcasting towers cause a growing number of fatal collisions with migratory birds. These structures sever migration routes, mostly of songbirds.

Two reasons are given for collisions with towers. The first is when birds flying in poor visibility do not see the structure early enough to evade it (blind collision). The second mechanism for mortality arises when there is a low cloud ceiling or nebulous conditions,

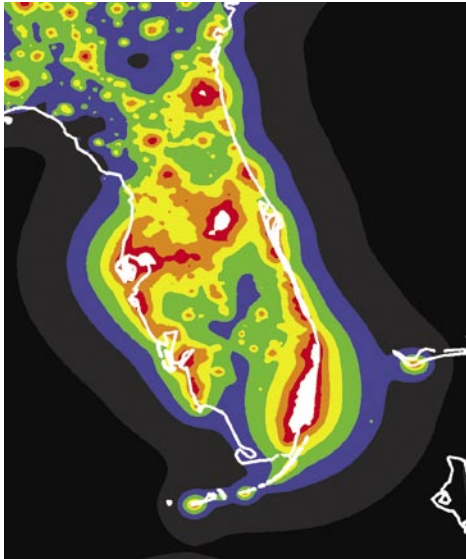


Figure 4. Image of Florida at night showing the extent of light pollution threatening the Everglades National Park, a World Heritage Site and Ramsar wetland, hosting one of the most remarkable biodiversity areas of our planet. Source: P. Cinzano, F. Falchi (University of Padova), C. D. Elvidge (NOAA National Geophysical Data Center, Boulder), 2001. *The first World Atlas of the artificial night sky brightness*. Monthly Notices of the Royal Astronomical Society, 328, 689-707. © Royal Astronomical Society. Reproduced from the Monthly Notices of the RAS by permission of Blackwell Science.

Threats to sea turtles

Effect on adult females

Artificial light has several effects on female turtles searching locations for nests and on hatchlings finding the sea. The female turtles avoid illuminated beaches for their nests with the effect that the nests are concentrated on the less illuminated and shaded

and lights on a tower refract off water particles in the air creating a lit up array around the tower. Birds lose their stellar cues for nocturnal navigation under these weather conditions. Furthermore, they lose all wide orienting perspective they might have on the landscape because they are flying beneath quite a low cloud ceiling. When passing the illuminated area, it could be that the increased visibility around the tower becomes the strongest cue the birds have for navigation, and as a result they tend to stay in the illuminated space near the tower. Mortality occurs when they fly into the structure and its guy wires, or even collide with other birds as more and more passing birds overcrowd the quite small, illuminated space.²²

Newer studies show that using rotating or blinking red lights and white strobe lights can reduce the effect of trapping birds at illuminated towers, but there is still work to do to improve the understanding of the whole effect on the migration process¹².

parts. This can cause a selection of a suboptimal nesting habitat or special concentration of nests, with effects on the number and sex ratio of hatchlings produced and higher hatchling mortality.^{13,17} The nesting behaviour itself can be affected by many factors. The overall nesting success of sea turtles in Florida is between 50% and 80%. The process can be abandoned when turtles encounter digging impediments, large structures, unsatisfactory thermal cues or human disturbance. After ending the nesting process, the turtles return to the sea. This process can be affected by artificial light. In a few cases, lights from car parks, road lighting and housing developments attract the turtles.

Effect on hatchling sea turtle orientation

The hatchlings themselves are affected by the sky glow and direct illumination too. The way that hatchling marine turtles find the sea is based on the fact that the nocturnal horizon over the sea is brighter than that over the land.^{10,13} The artificial light of street lamps, houses or sky glow of cities, especially on nights with little or no moon, can dis- or misorientate the hatchlings on their way to the sea. Because of these orientation problems, the hatchlings crawl in the wrong direction where they are threatened by dehydration, predators, and high temperatures after sunrise.

Solutions

To minimise the negative effects of artificial lighting, new strategies of light management are necessary. Light must be used more precisely. It should be less intensive and in longer wave-lengths so it is less disruptive to the wildlife. The regulations must be implemented through laws as is already done in most counties in Florida for example.^{8,13}

Threats to fish

Reaction (attraction and avoidance) of fish to artificial light depends on the species but affects their natural behaviour in both ways. There are several studies on the use of artificial light at fish farms and deep-sea fish. Most of the studies show that fish avoid white light sources. Nevertheless, there are species that are attracted by light and this is used to catch them by sport anglers or industrial fisheries.

Light attraction method to catch Mukene

Light attraction is widely used by anglers to catch fish in the dark. The FAO reports that fishing with floating lamps is used at Lake Victoria to catch the Mukene using scoop-nets and nets pulled from the shores (beach seines) and from canoes (lampara nets). This method can endanger nursery grounds for immature Mukene, Nile perch and Tilapia because it is used in shallow waters near the coastlines³.

Salmon farms

Submerged light increases swimming depth and reduces fish density of Atlantic salmon in production cages. These artificial photoperiods are used to postpone sexual maturation and increase growth. Studies in these farms suggest that salmon position themselves in relation to the artificial light gradient to maintain schooling behaviour⁶.

Halibut farms

Light used in Halibut farms influences their swimming behaviour. Artificial light influences the swimming depth and the swimming activity: Halibut swim less and grow more. It may be that the fish are particularly sensitive to ultraviolet damage. Evidence of damage (skin lesions, etc.) has been observed in Halibut. This is particularly the case for fish that are acclimatised to indoor conditions, and which are moved out in the spring, when the sun is most intense. Farmers can protect their stock with the use of shade nets.⁴

Deep-sea fish

A study of lighting techniques in deep-sea fish observation pointed out that white light disrupts the natural behaviour of deep-sea fish. Observations showed that the “average number of fish appearances on camera was significantly greater under red light than white light”¹⁶. Reasons are the adaptation of the eyes of deep-sea fishes to the dark environment and the possible damage to eyes by bright lights.



Figure 5. Mainly diurnal, the Madagascan golden frog (*Mantella aurantiaca*) restricts its reproductive activity at night. © G. Orlando

Conclusion

The variety of environmental conditions is important because it contributes to the partition of resources and greater biodiversity. Various natural processes can only happen during the night in darkness. Examples are resting, repairing, celestial navigation, predating or charging of systems. For this reason, darkness has the equal and amendatory functional importance as daylight. It is indispensable for the healthy functioning of organisms and whole ecosystems.

Recommendations

- Much more research is needed on the effects of light pollution
- Public and government awareness shall be intensified in view of the value of protection, avoidance and decrease of light pollution. Public opinion would need to be shifted regarding light trespass and “second hand” light, the wastefulness of excessive night lighting and the importance of using the right lighting for the right situation.
- Legislation needs to be developed to support and require dark sky friendly lighting through by-laws, modified engineering standards and building codes¹⁹.

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