

# LIGHT AND NOISE POLLUTION

Many studies show that environmental noise is harmful to humans and animals. Also, excess artificial light has a destructive effect on ecosystems.

The brightly-lit downtown business district of Doha, the capital of Qatar



MAREK KUCHARCZYK

## Marek Kucharczyk Marcin Polak

Institute of Biology  
Maria Curie-Skłodowska University in Lublin

**L**ight, especially visible light, carries the energy that plants need for photosynthesis, and so it is of fundamental importance for all life on Earth. Both light and sound also serve living organisms as carriers of information about the surrounding environment. Therefore, any human-induced changes in the radiation present in the natural environment or changes in the vibrations of sound-carrying media can be regarded as a kind of environmental pollution.

### A brightly-lit Earth

The advancement of human societies inevitably means the increasing use of artificial light sources. Light gives people a sense of security (especially at night), allows a significant extension of human activity, and is the carrier of most of the information that reaches the human body. The use of artificial light sources on a massive scale means that in developed countries most of the population never experiences a night darker than a full moon. At the start of the twenty-first century, this was true for 80% of the population in the United States and 67% in the EU, whereas now it is true for more than 70% of all EU residents. The surface of areas artificially illuminated at night is increasing by 2.2% annually, and the intensity of light emitted by 1.8%.

The impact of light pollution extends to most organisms that live in proximity to humans. The consequences of this can be considered at several levels: the physiological, individual, population, and ecosystem levels. For plants, which function based on visible light energy, an increase in the amount of light does not significantly affect their functioning. However, disruption of the seasonal rhythm of the length of daylight and night results in disturbances in plant growth, flowering, bud development, dormancy, and resource allocation. The disruption of their stomatal regulation causes plants to lose more water through transpiration, potentially leading to a negative water balance and exposure to continuous infiltration of gaseous pollutants.

The human physiological responses to extended daylight and shortened nighttime are well studied. The biological clock, which controls the production of melatonin in the pineal gland, is disturbed. Melatonin is a hormone produced and secreted into the blood

normally only during the dark part of the day; it is an antioxidant, cytostatic substance that regulates the cellular balance from proliferation to differentiation, and can also promote apoptosis of cancer cells. Prolonged nighttime activity and the attendant reduced melatonin production are well-known to be associated with heightened risk of developing breast cancer, prostate cancer, and other cancers. The International Agency for Research on Cancer (IARC WHO) has categorized diurnal rhythm disorders into group 2A as a “probable carcinogen.”

Shift work that includes stages of nighttime work is also associated with a greater risk of developing metabolic syndrome, hypertension, inappropriate blood lipid levels, obesity and type II diabetes. A UK study of more than 100,000 women found a link between bedroom brightness and obesity. This is attributed to the desynchronization of internal clocks, shortened sleep and unnatural mealtimes, which promote metabolic disorders.

### The nightlife of animals

An increase in light intensity beyond natural levels affects the behavior of predators and their prey. The ability to forage at night under artificial light conditions is referred to as the “light-night niche.” However, if light levels are too high, there is an avoidance response, as the risk of a predator being detected by potential prey increases. Artificial lighting can delay or even prevent prey from becoming nocturnally active – such as nocturnal butterflies. Reproductive activity in amphibians is also known to decrease under the influence of artificial lighting, such as near permanently-lit roads or industrial and commercial facilities. The well-known effect of insects being attracted to point sources of light, such as streetlamps, results in reduced local diversity. A study in Germany has reported that the streetlamps used in a city with a population of nearly 240,000 may be responsible for the death of up to 360 million insects a year.

It is important to understand the different spectral characteristics of artificial light sources and the reactions caused by them. The way light is perceived differs significantly between humans and different groups of animals. Birds, for instance, are able to see ultraviolet light thanks to the fact that they have four types of cones in their retina. Insects, especially butterflies, have a wide spectrum of visual perception.

The information that animals perceive in ultraviolet or polarized light can unfortunately get masked or distorted by artificial light sources. Birds gain their spatial orientation based on a system that registers the Earth’s magnetic field, and variations in natural lighting help calibrate this system. Large urban areas, with strong point sources of light, can mask the informa-



**Marek Kucharczyk,  
PhD, DSc**

works in the Department of Zoology and Nature Conservation at the UMCS. His research topics include a wide variety of issues related to species ecology, nature conservation, and the environment.  
marek.kucharczyk@mail.umcs.pl



**Marcin Polak,  
PhD, DSc**

works in the Department of Zoology and Nature Conservation at the Maria Curie-Skłodowska University in Lublin. He specializes in the ecology and vocalization of poorly known, secretive, and endangered bird species.  
marcin.polak@mail.umcs.pl

tion carried, for instance, by the polarized light from the sky, therefore disrupting the migration of many bird species. Variations in the light coming from the night sky over the sea or ocean provide information based on which turtles hatching on the beach head for the water.

Polarized light reflected from the surface of water serves as a signal to many species of the presence of a suitable environment for laying eggs (at least 300 species of insects) – both to wetland birds that looking for places to rest or feed, and to predators that feed on them. Smooth, light-reflecting surfaces such as the façades of modern buildings, large glass windows, wet road surfaces, parking lots, and even oil stains or car bodies can act as ecological traps for both kinds of species.

## Cutting through the noise

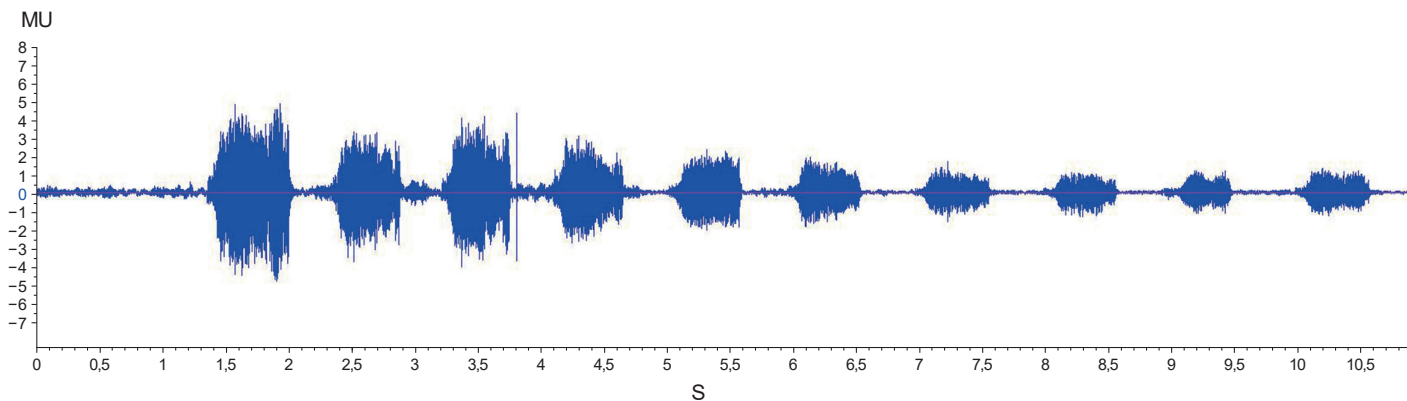
Over the past century, excessive levels of human-generated noise have become a major environmental problem in aquatic and terrestrial ecosystems around the world. Various animal communication systems

evolved in specific natural sound environments. Over millions of years, organisms have adapted the parameters and structure of their calls and mating songs to the local acoustic background profiles of their habitats. Some animal species are highly adapted to living with a high intensity of surrounding sounds (natural or artificial). For example, for parent birds living in noisy breeding colonies of many thousands of individuals, recognizing the vocalizations of their own offspring can certainly pose a major challenge. Moreover, anyone who has visited an old-growth forest or park in Poland around dawn in the month of May will have noticed that birds are forced to sing their songs daily against a loud chorus of serenades from other species.

However, the rapid growth in the global human population, swift urbanization, armed conflicts, the expansion and greater density of sea and land transportation routes all contribute to increased global noise pollution. Nowadays, various organisms are finding it increasingly difficult to live in a world saturated with artificial sounds generated by human activity.

Map of light pollution in Poland in 2020 (according to World Atlas of the Artificial Night Sky Brightness, <https://djllorenz.github.io/astronomy/lp2020/overlay/dark.html>)





Oscillogram of a call emitted by a duet of a male and a female water rail

Numerous studies indicate that excessive sound emissions as a result of urbanization and transportation and industrial development disrupt sound communication and negatively affect the abundance and distribution, breeding success, adaptation, fitness and health of many species of insects, fish, amphibians, birds and marine and terrestrial mammals. Most research projects focus on determining the impact of noise on the sound communication of birds, in which we are dealing with extremely complex strategies for exchanging information between individuals.

The main problem for individual organisms living in heavily noise-polluted environments is that the natural transmission of sound stimuli via animal communication networks – composed of senders, receivers and also eavesdroppers – gets drowned out. Recent studies show that in noisy areas, females cannot hear or only faintly hear the calls of their potential mates and so are unable to make good judgments about their fitness and attractiveness. Males may have trouble hearing their rivals and neighbors. Parents cannot adjust the pace of feeding their chicks when the young birds' begging calls are drowned out by noise. Social birds living in groups cannot hear the warning calls emitted to inform fellow group members of an approaching predator.

## Avian slums

In the mid-1990s, Dutch researchers noted that the density and species richness of avian communities living near highways and expressways were relatively low. These indicators gradually increase with increasing distance from the edge of the road. This same regularity has been confirmed by numerous studies along transportation routes in other parts of the world. Three groups of birds have begun to be distinguished: (1) sensitive and stenotopic species that avoid the vicinity of roads, (2) neutral species that nest at similar densities both near and far from transportation routes, (3) cosmopolitan eurytopic species, which actually prefer habitats near roads and railroads (the “edge effect”).

Transportation routes typically slice through what were previously uniform habitats, modifying the availability and abundance of the food base, changing vegetation structure, microclimate characteristics (e.g., insolation), and predation pressure, among other factors. For example, many bird species use power lines along railway embankments as perches and foraging spots, while scavengers regularly patrol the area around transportation corridors in search of collision victims. However, the vicinity of roads can act as an ecological trap, as birds attracted in by certain resources may die in collisions with vehicles and/or attain lower breeding success.

The ornithologist Henrik Brumm was the first to demonstrate the possibility that birds might actively adjust the intensity of their songs to varying acoustic backgrounds. He found that male nightingales sang 10–20 dB louder in parts of Berlin polluted by road noise than in quiet and peaceful areas of the city. This is the so-called Lombard effect, named after the French surgeon and otolaryngologist Étienne Lombard. In 1911, Lombard described the phenomenon in which individuals tend to alter the parameters of their voice emission in order to improve audibility. This is why we tend to speak louder at concerts and house parties. The Lombard effect can also involve modifying other acoustic parameters and structure – for instance, great tits inhabiting noisy areas in Leiden (western Netherlands) were found to sing mating songs with a higher minimum frequency than individuals in quiet and peaceful places. This allows flexible singers to overcome the masking effect. Road noise is characterized by a low frequency spectrum, and singing in a higher pitch helps them bypass this problem and reach out to potential audiences more effectively.

More and more animals on our planet are being negatively affected by human-induced acoustic disturbances. Scientists continue to discover new adaptations made by organisms to live in noise-polluted ecosystems, as well as new sources of noise – for example, due to the war in Ukraine, the use of submarine radar is drowning out the calls of cetaceans in the Black Sea and causing them to become disoriented. ■

### Further reading:

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