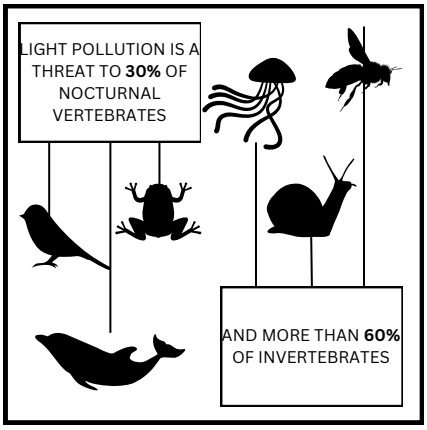
NATURE'S VALLEY
CONSERVANCY / ULONDOLOZO / BEWAREA

Shining a Light on Darkness: Understanding and Mitigating Light Pollution

Light pollution and its effects in Nature's Valley

Ecological light pollution refers to artificial light that disrupts the natural patterns of light and dark in ecosystems, caused by exposure to both nearby and distant light sources, as well as sky brightness. This phenomenon has become a global issue, particularly in economically developed regions, where light-polluted skies are now a common reality. Over time, increased sky brightness has eroded natural darkness, encroaching even on protected terrestrial and marine areas.

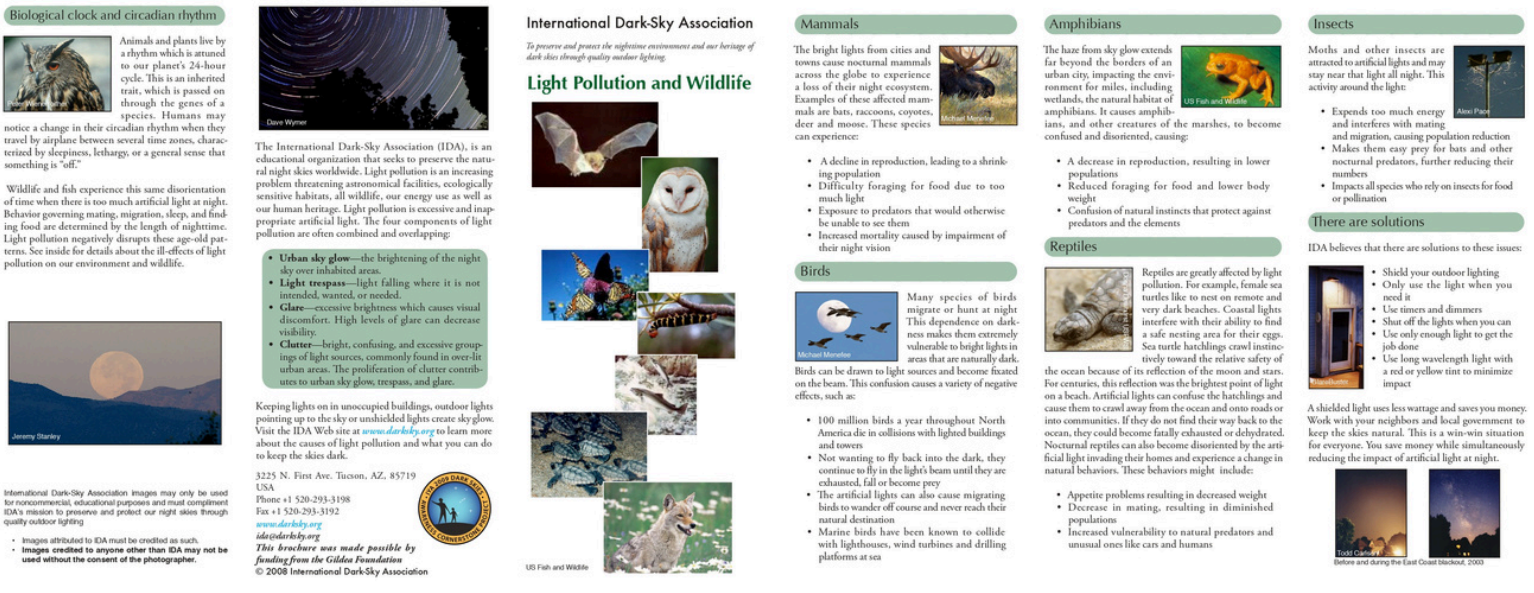


Anthropogenic light exacerbates climate change through heightened energy consumption while presenting significant challenges to various species and ecosystems. Its harmful effects have been extensively studied across multiple species groups, including bats, insects, seabirds, fish, and other vertebrates, as well as marine, shoreline, and estuarine organisms. Research has revealed substantial impacts across these groups, demonstrating diverse and far-reaching effects that manifest at different trophic levels. These studies have significantly enhanced our understanding of ecological light pollution, raising awareness of its environmental consequences.

The adverse effects of artificial lighting can be categorized into three key areas:

- Ecological Disruption: Displacement of species and alteration of natural behaviors.
- Energy Consumption: Increased carbon footprint due to excessive use of lighting.
- Human Health Impacts: Potential disturbances to circadian rhythms and overall health.

https://darksky.org/



Biological clock and circadian rhythm

Animals and plants live by a rhythm which is attuned to our planet's 24-hour cycle. This is an inherited trait, which is passed on through the genes of a species. Humans may notice a change in their circadian rhythm when they travel by airplane between several time zones, characterized by sleepiness, lethargy, or a general sense that something is "off."

Wildlife and fish experience this same disorientation of time when there is too much artificial light at night. Behavior governing mating, migration, sleep, and finding food are determined by the length of nighttime. Light pollution negatively disrupts these age-old patterns. See inside for details about the ill-effects of light pollution on our environment and wildlife.

Jeremy Stanley

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Dave Wyner

The International Dark-Sky Association (IDA), is an educational organization that seeks to preserve the natural night skies worldwide. Light pollution is an increasing problem threatening astronomical facilities, ecologically sensitive habitats, all wildlife, our energy use as well as our human heritage. Light pollution is excessive and inappropriate artificial light. The four components of light pollution are often combined and overlapping:

- **Urban sky glow**—the brightening of the night sky over inhabited areas.
- **Light trespass**—light falling where it is not intended, wanted, or needed.
- **Glare**—excessive brightness which causes visual discomfort. High levels of glare can decrease visibility.
- **Clutter**—bright, confusing, and excessive groupings of light sources, commonly found in over-lit urban areas. The proliferation of clutter contributes to urban sky glow, trespass, and glare.

Keeping lights on in unoccupied buildings, outdoor lights pointing up to the sky or unshielded lights create sky glow. Visit the IDA Web site at www.darksky.org to learn more about the causes of light pollution and what you can do to keep the skies dark.

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International Dark-Sky Association

To preserve and protect the nighttime environment and our heritage of dark skies through quality outdoor lighting.

Light Pollution and Wildlife

US Fish and Wildlife

Mammals

The bright lights from cities and towns cause nocturnal mammals across the globe to experience a loss of their night ecosystem. Examples of these affected mammals are bats, raccoons, coyotes, deer and moose. These species can experience:

Michael Menefee

- A decline in reproduction, leading to a shrinking population
- Difficulty foraging for food due to too much light
- Exposure to predators that would otherwise be unable to see them
- Increased mortality caused by impairment of their night vision

Birds

Michael Menefee

Many species of birds migrate or hunt at night This dependence on darkness makes them extremely vulnerable to bright lights in areas that are naturally dark. Birds can be drawn to light sources and become fixated on the beam. This confusion causes a variety of negative effects, such as:

- 100 million birds a year throughout North America die in collisions with lighted buildings and towers
- Not wanting to fly back into the dark, they continue to fly in the light's beam until they are exhausted, fall or become prey
- The artificial lights can also cause migrating birds to wander off course and never reach their natural destination
- Marine birds have been known to collide with lighthouses, wind turbines and drilling platforms at sea

Amphibians

The haze from sky glow extends far beyond the borders of an urban city, impacting the environment for miles, including wetlands, the natural habitat of amphibians. It causes amphibians, and other creatures of the marshes, to become confused and disoriented, causing:

US Fish and Wildlife

- A decrease in reproduction, resulting in lower populations
- Reduced foraging for food and lower body weight
- Confusion of natural instincts that protect against predators and the elements

Reptiles

Reptiles are greatly affected by light pollution. For example, female sea turtles like to nest on remote and very dark beaches. Coastal lights interfere with their ability to find a safe nesting area for their eggs. Sea turtle hatchlings crawl instinctively toward the relative safety of the ocean because of its reflection of the moon and stars. For centuries, this reflection was the brightest point of light on a beach. Artificial lights can confuse the hatchlings and cause them to crawl away from the ocean and onto roads or into communities. If they do not find their way back to the ocean, they could become fatally exhausted or dehydrated. Nocturnal reptiles can also become disoriented by the artificial light invading their homes and experience a change in natural behaviors. These behaviors might include:

- Appetite problems resulting in decreased weight
- Decrease in mating, resulting in diminished populations
- Increased vulnerability to natural predators and unusual ones like cars and humans

Insects

Moths and other insects are attracted to artificial lights and may stay near that light all night. This activity around the light:

Alexi Pace

- Expends too much energy and interferes with mating and migration, causing population reduction
- Makes them easy prey for bats and other nocturnal predators, further reducing their numbers
- Impacts all species who rely on insects for food or pollination

There are solutions

IDA believes that there are solutions to these issues:

- Shield your outdoor lighting
- Only use the light when you need it
- Use timers and dimmers
- Shut off the lights when you can
- Use only enough light to get the job done
- Use long wavelength light with a red or yellow tint to minimize impact

A shielded light uses less wattage and saves you money. Work with your neighbors and local government to keep the skies natural. This is a win-win situation for everyone. You save money while simultaneously reducing the impact of artificial light at night.

Todd Gehrke

Before and during the East Coast blackout, 2003

Birds

One of the most established effects of anthropogenic light on birds is their response to it during migration. Many birds, including otherwise diurnal species, migrate at night. They are attracted to light and disoriented by it, especially strong light sources and bright spots in dark areas. This attraction to light can not only cause them to collide with buildings, lighthouses, oil rigs, and ships, but may also divert them from suitable stopover locations. Migratory routes are often close to illuminated urban areas. In areas with dark surroundings, such as islands, light sources attract seabird fledglings.





These effects can directly result in high mortality and exhaustion. Many other effects are less pervasive but still problematic; for example, light may induce stress and disturb sleep. Many bird species in temperate zones depend on the accurate seasonal timing of breeding and the accurate daily timing of song activity and foraging, so light disturbance of this temporal organization is problematic.

Nocturnal rodents are less active, and diurnal species can be restless in illuminated nights. Birds advance their dawn song, and bats delay emerging until the evening. Light at night can disrupt the perception of day length in birds, causing them to breed earlier in spring.

Mammals

Most bat species are highly nocturnal and respond strongly to light. This response is driven by the fear of predators or the foraging ecology. For example, fast-flying, agile bats are less frightened by light and forage on accumulated insects around light sources, whereas slow-flying bats stay in sheltered locations. Bats are particularly vulnerable because they use linear landscape elements such as forest edges, hedgerows, and streams to guide them in foraging and commuting. Light along commuting and foraging routes can act as a barrier, thereby amplifying its negative effects by fragmenting habitat networks. Anthropogenic light in or near bat roosting sites can lead to delayed emergence or roost abandonment, which has negative consequences for the survival of populations.

A commonly accepted assumption is that, like bats, other nocturnal mammal species' responses to light are driven by fear of predators. A decrease in the activity of nocturnal species by light at night has been reported in numerous laboratory experiments. Many mammal species reduce activity in response to moonlight and show a comparable response to anthropogenic light. Likewise, anthropogenic light can change the spatial behaviour of rodents and, even in the absence of predation, reduce longevity and reproduction. Larger mammal species such as bushbuck and predators may also change their spatial activity. On a larger scale, the deterrent effects of light on infrastructure may have far-reaching effects because mammals may stop using passage structures. As is the case with many other species, anthropogenic light can have profound effects on mammals' daily and seasonal rhythms of activity, physiology, and reproduction.

Invertebrates

The attraction of insects to light is a well-known phenomenon. In naturally dark environments, insects can be attracted to low light intensities, and the extent of attraction to a light source depends on the presence of surrounding lights. Insect's flight-to-light may be a maladaptive response to the original orientation toward moonlight and is related to colour composition. Blue light (<500 nm) attracts more insects than the yellow and red parts of the spectrum. The attraction of insects to anthropogenic light may cause mortality and exhaustion, which may play a substantial role in global insect declines. This has been corroborated by the fact that phototactic nocturnal species that fly toward light have shown strong population declines. Indeed, light posts have been found to affect local moth caterpillar abundance. Moreover, insect declines can be caused by the negative effects of light on reproduction and development. Insects that depend on bioluminescent signalling, such as fireflies, are especially vulnerable to anthropogenic light and are directly impaired in reproduction. Anthropogenic light deprives insects such as aquatic insects and dung beetles of their ability to use light cues for orientation. For several other invertebrate groups, the effects of light are well documented, including opportunistic foraging around light sources by spiders and slugs. Finally, anthropogenic light can change species composition in invertebrate communities.

Amphibians

Early field observations have provided evidence that anthropogenic light affects the reproduction, visual performance, and activity patterns of amphibians. In toads, exposure to anthropogenic light has been found to cause reduced activity levels, altered energy allocation, and decreased juvenile growth and metamorphic duration. Anthropogenic light can also alter breeding behaviour and reduce the fertilization success of toads. In frogs, although mate choice behaviour appears to be unaffected by anthropogenic light, it has been shown to shorten the calling season and shift the daily calling period.

Reptiles

Knowledge about the impact of anthropogenic light on reptiles in general is limited, but its effect on marine turtle populations is widely known. Hatchlings are highly susceptible to disorientation caused by light when crossing the beach to reach the sea, leading to high mortality rates. Furthermore, even at low levels, anthropogenic light can disrupt the on-beach orientation of turtles, resulting in suboptimal selection of nesting sites. Turtle nests have declined in lit areas across several species, with turtles using lit beaches less frequently or avoiding them altogether. Some diurnal reptiles, such as geckos, are able to forage at night in the presence of anthropogenic light. Likewise, green anole lizards (Anolis carolinensis) express part of their normal daytime foraging and display activity during the night.





Fish

Compared with terrestrial organisms, fish have received less attention in studies investigating the effects of anthropogenic light. Such light may affect fish populations through changes in survival rates, spawning, hatching success, and physiology, and can alter the temporal and spatial activity of fish and increase their energy expenditure. This can stimulate various behaviours such as nest-guarding activity, higher nocturnal activity, overall activity during both day and night, increased time spent in open areas, and maintaining position in an area. Fish species can be attracted or repelled by light. For example, positive phototaxis can lead to the aggregation of smaller fish around lighting, thereby providing easy prey for predatory fish. Some species may benefit from foraging under brighter conditions, but whether the benefits outweigh the costs over time is still being determined. Very low light levels can have effects on fish behaviour. For example, rainbow trout (Oncorhynchus mykiss) are attracted to low levels of bridge illumination, which further depends on various environmental factors, making it a complex issue.

Plants

Although the effects of anthropogenic lighting on commercially grown plants are well documented, there is a gap in the knowledge about its effects on plants and plant-mediated responses in the natural environment. Lighting close to trees can lead to increased photosynthesis and morphological changes through the relocation of biomass from roots to leaves. In deciduous trees, exposure to anthropogenic light advances the emergence of leaf buds and, together with temperature, delays the colouring of leaves. Species-specific variations in responses to anthropogenic light have also been demonstrated in herbs and grasses.



Ecosystem effects of anthropogenic light

Forest ecosystems are generally darker as light is filtered through and absorbed by the vegetation, and only a small proportion of ambient light reaches the ground. Species that inhabit forests are believed to have adapted to darker nocturnal environments. In open environments, light can propagate far from the source, and even a single strong light can be a conspicuous element in the landscape, resulting in glare and difficulties in seeing details in the surroundings and stars in the night sky. In general, open environments are perceived as brighter when larger parts of the naturally lit sky and the ground can be viewed. Low-growing and light-green vegetation such as grasses, bushes, and herbs can reflect a high proportion of light, which increases the luminance of the landscape.

In **aquatic** ecosystems, anthropogenic light is reflected on water surfaces and thus has a high probability of propagating widely over open water and may affect large areas. Examples like sea turtles, which may fail to find the ocean after hatching due to beach lighting and zooplankton, which avoid well-lit areas, thus disrupting food webs

Many human structures in or near aquatic ecosystems, such as ports, ships, and oil rigs, use high-intensity lighting with insufficient restrictions, often resulting in large amounts of light spilling into the surroundings. In water, light changes with depth. Water and its particulates absorb and scatter light, reducing light intensity, altering colour composition, and changing the degree of polarization. Clear ocean waters absorb ultraviolet, red, orange, and yellow wavelengths at the top of the water column, allowing blue light to penetrate the deepest, which results in a bluer colour at greater depths. Coastal and freshwater systems often contain suspended particulates and phytoplankton, which selectively absorb the light, causing the water to appear more yellow-green, orange, or brown in colour. Aquatic species have adapted their eye morphology to natural variations in intensity and colour composition with photoreceptors that match the colour of light, thereby increasing photon absorption. For example, deep-sea fishes have a visual pigment that matches the colour of downwelling oceanic light, whereas fish species found in yellow-green coastal waters and inland freshwater lakes have photoreceptors with absorption peaks at longer wavelengths. Because light diminishes with depth, organisms in the mesopelagic zone have adapted to more dim light conditions with larger eye size and wider pupils. Aquatic species are expected to be vulnerable to anthropogenic light at night because of their high photosensitivity at low illuminance, which is an adaptation to decreased light intensity as light is filtered out by water.

Effects of anthropogenic light on temporal organization

Light is the key driver of the most important temporal niches in nature. The contrast between high light levels during the day and low levels at night enables species to share the same habitat within a 24-hour cycle. For most species, photic conditions are essential for their ability to survive. Organisms need to optimally schedule activity, rest, and sleep in (species-specific) natural light conditions.
The disturbance of rhythms in natural systems by light at night has attracted increasing interest, particularly in laboratory studies. For example, great tits (Parus major) exposed to low light levels during the dark phase of the light cycle were found to advance the start of their daily activities [e.g.,]. Rhythms in laboratory mice were shown to be weakened by dim light at night, and their hormonal rhythms were affected. Light at night has also been shown to disrupt circadian gene expression in great tits. In the field, an advanced onset of dawn song has been observed for several bird species, and individual blackbirds (Turdus merula) exposed to higher levels of anthropogenic light begin their activity earlier in the day. By contrast, nocturnal species respond to light by delaying their activity. For example, least horseshoe bats (Rhinolophus pusillus) emerge later, when their roost is illuminated. Bird species that normally start their dawn song relatively early during still low light levels, such as the robin (Erithacus rubecula), respond more strongly to the presence of artificial light compared with other birds (e.g., the blue tit, Cyanistes caeruleus) that start dawn song later in the morning.



In temperate zones, anthropogenic light interferes with the annual cycle of species. Trees delay shedding leaves from branches close to streetlights. Anthropogenic light can advance reproduction in birds, delay reproduction in mammals, and prolong yearly reproduction in insects.

Anthropogenic light affects interactions and trophic levels

Changes in the population of a species caused by anthropogenic light inevitably cause changes in the food web. Light can facilitate foraging for predators by concentrating prey species, such as for synanthropic bat species that catch light-attracted flying insects. Such changes in the predator–prey interaction may, however, be part of a trade-off for bats because they need to prevent exposing themselves too much. Foraging may be further facilitated by providing better visual detection of prey, as was shown for burrowing owls (Athene cunicularia), which could expand their foraging habitat into urbanized areas using the presence of anthropogenic light. Conversely, prey species may avoid illuminated, otherwise suitable habitat or change foraging behavior. Such changes have been shown in jerboas (Allactaga sibirica), which spend less time searching for food in illuminated conditions. Likewise, in aquatic systems, light at night can counteract the benefits of shelter material for amphipods (Gammarus fossarum) seeking shelter from the predatory Eurasian perch (Perca fluviatilis).
Complex effects have been reported about the interaction of urbanization with the response to light. In urban areas, mule deer (Odocoileus hemionus) use illuminated foraging grounds but are then exposed to predation by cougars (Puma concolor), which potentially results in an ecological “trap” in which species may do worse in an ostensibly beneficial situation.

Trophic interactions can form the basis of key ecosystem services such as pollination by insects. Nocturnal pollination is strongly affected by anthropogenic light, and reduced nocturnal pollination
rates are compensated for by diurnal insects. The disturbance of trophic interactions by light at night in plant–herbivore communities can be complex and depend on species and colour composition. To understand ecosystem-wide changes, a better understanding of trophic interactions is essential.

Anthropogenic light affects species at different time scales

The attraction of animals to light is a well-known direct response. Anyone who is attentive will notice the accumulation of insects around light sources. Attraction has been reported in many other species groups, such as marine turtles, birds, and amphibians, and often has direct consequences for survival and subsequently for populations. Because the removal of light sources is very rare, it is important to assess effects that may only manifest after a long period of time. Several studies have shown indirect effects of anthropogenic light on many insect species. Adult fireflies survive light sources in proximity but fail to attract mates, which eventually results in population decline. Moth species, in addition to the agony of being trapped near light sources, are burdened by impaired reproduction and development. Light at night affects gonadal growth in blackbirds, which manifests only during the second year of exposure. Ultimately, light at night may cause adaptive changes, but evidence is limited to just a few studies. These include the examples of potential adaptation in spiders (Larinioides sclopetarius) with the innate preference for building webs around anthropogenic light sources and in urban moths that show reduced flight-to-light behaviour compared with rural conspecifics.

Jägerbrand, A. K., & Spoelstra, K. (2023). Effects of anthropogenic light on species and ecosystems. Science, 380(6650), 1125-1130. https://doi.org/10.1126/science.adg3173

Energy Consumption and Carbon Footprint

Increased Energy Use: Artificial lighting, especially inefficient lighting, contributes significantly to energy consumption. This results in higher greenhouse gas emissions from power plants, contributing to global warming and climate change.
Resource Depletion: The production and maintenance of lighting systems consume natural resources, from the extraction of raw materials to the energy required for manufacturing and transportation.

Human Health Impacts

Disruption of Circadian Rhythms: Exposure to artificial light, especially blue light from screens and LEDs, can disrupt human circadian rhythms. This can lead to sleep disorders, reduced melatonin production, and various health issues such as increased risk of obesity, depression, and cardiovascular diseases.

What you can do

1. Placement - Outdoor lighting to be angled downwards, Shielded from direct view and low as possible to the ground.
2. Wattage - Outdoor lighting not to exceed 25 incandescent or 3.5 LED watts.
3. Wavelengths - Bulbs using longer wavelengths (560nm or greater)
4. Light fixtures - No light above the outdoor fixture.
5. Timers - Programmed for limited use.
6. Motion activated lighting - Only turns on when triggered.
7. Indoor lighting mitigation - Install shutters
8. Holiday decorations - Temporary displays with automatic shut-off timer.



Addressing the negative effects of lighting on our environment requires a concerted effort to adopt sustainable practices and technologies that balance our need for illumination with the health of our ecosystems and communities.

https://darksky.org/resources/what-is-light-pollution/effects/wildlife-ecosystems/
https://www.science.org/content/article/flying-insects-night-light-hampers-upright-flight
https://www.youtube.com/watch?v=u0DjTJf4n4Y