

# The Impact of Nighttime Lighting on Nocturnal Birds

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**Abstract.** In recent years, humans have made great progress in the field of night sky lighting, which has increased the convenience of people's lives. However, a problem that cannot be ignored is that artificial night lighting poses a threat to the survival of birds, to the detriment of their population and biodiversity. To address this issue, this paper investigates the impact of nighttime lighting on nocturnal birds in certain areas and explores effective measures to solve these problems. The data from this paper show that night lighting can affect the nocturnal navigation ability of birds, causing them to lose their direction or die during their migration. Secondly, this artificial lighting also alters the breeding behavior of birds, reducing the success rate of breeding. Moreover, night lighting becomes a major threat to bird deaths by increasing the collisions between birds and urban buildings. Finally, night lighting also leads to the adjustment of birds' vision. This research article aims to raise public awareness of bird protection across all sectors of society, enhance people's understanding of the plight of birds' survival, and thereby encourage everyone's determination to protect birds.

**Keywords:** Nocturnal birds, nighttime lighting, protection.

## 1. Introduction

Nighttime artificial lighting significantly impacts nocturnal birds through behavioral disruption, physiological stress and evolutionary adaptations. Bird reproduction and survival are greatly affected and life safety is threatened. For the disruption of magnetic orientation, artificial lighting interferes with the magnetic compass of migratory birds. The 41-story skyscraper's façade and roof lighting caused mass disorientation among migratory birds (e.g., passerines), leading to collisions with the building or exhaustion-related fatalities due to light pollution [1]. For physiological stress responses, Urban songbirds nesting under white LED street lights showed elevated corticosterone levels, a stress hormone linked to nest abandonment. Artificial light's effect in the evening on Eurasian tree sparrows mainly includes the rhythm of daily behavior disorders, sleeping hormone inhibition, plus changes in gut small microorganisms' living circumstances [2]. Artificial lighting typically lacks ultraviolet wavelengths, so captive birds raised under such lighting may have an impact on their welfare while raising quails without ultraviolet light does not seem to have a significant effect on their welfare [3]. Importance Hundreds of millions of birds are killed each year in North America alone as a result of collisions with constructed buildings. Because artificial lighting attracts and confuses nocturnally migrating birds, light pollution is a significant contributor to collision mortality, and efforts to mitigate the effects of light on migratory birds are gaining traction. Twenty years of data indicate that migration range, electricity utility, and wind state are crucial, predictive factors for an extremely high building collision in Chicago, and reducing the area of daylight windows can reduce bird mortality by about 60%. Turning off lights can effectively eliminate birds' mortality, which has global significance in supporting conservation initiatives that seek to eradicate significant factors contributing to avian mortality [4]. On a global scale, artificial light in the evening accesses birds easily. Nighttime lighting has a severe impact on all species at different nutritional degrees. Nevertheless, the impact of human-made lighting systems on biological circumstances remains largely to be determined. The illumination level of artificial lighting at night is similar to that of roadside vegetation, and population effects can be regulated through comprehensive impacts on the ecosystem. Considering the ascending prevalence of nighttime light pollution, these factors may be widely present in the circumstance, highlighting the significance of minimizing ecosystem damage by reducing light pollution in all ecosystems [5]. If left unaddressed, these trends may accelerate, leading to local extinction.

## 2. The Impact of Nighttime Lighting on the Energy Depletion of Birds

Nighttime lighting, an increasingly prominent feature in modern human-dominated landscapes, has emerged as a significant and growing concern for the well-being of nocturnal birds. It poses a multifaceted threat that directly and indirectly leads to substantial energy depletion in these avian creatures, disrupting their natural life cycles and endangering their survival and population sustainability. This issue has become a critical area of study in the fields of ornithology and conservation biology, with far-reaching implications for both the birds themselves and the ecosystems they inhabit.

### 2.1. Disruption of Activity Rhythms

The internal biological clocks of birds are exquisitely calibrated mechanisms that govern their daily routines, including periods of rest, foraging, and migration. These circadian rhythms are finely attuned to natural light-dark cycles, enabling birds to optimize their energy use and survival strategies. However, the advent of widespread nighttime lighting has thrown a wrench into this delicate system, disrupting the normal activity rhythms of countless bird species.

When given NPY *ivt*, white-crowned sparrows eat more, become more sensitive to photostimulation, and gain weight. Therefore, NPY might be a natural food intake stimulant for this species [6]. In this city, the extensive network of streetlights, commercial signage, and building facades that emit illumination throughout the night has created an artificial day-like environment. The white-crowned Sparrow (*Zonotrichia leucophrys*), a common migratory species in the region, has been particularly affected. Under normal circumstances, the white-crowned sparrows rely on the darkness of night to enter a state of rest, during which their metabolic rates slow down, and they conserve energy for the challenges of the next day, such as foraging and migration. However, in the light-polluted areas of Denver, these birds are forced to remain active well into the night. The persistent glow of artificial lights tricks their biological clocks into thinking it is still daytime, prompting them to engage in activities that they would typically reserve for daylight hours.

The researchers used a combination of techniques, including attaching tiny sensors to individual birds to monitor their activity levels, heart rates, and energy expenditure. The data revealed that the white-crowned Sparrows exposed to nighttime lighting consumed approximately 30% more energy during a single migration season compared to those in areas with natural lighting conditions. This additional energy consumption can have severe consequences. Birds rely on their stored energy reserves to fuel their long-distance migrations, and any significant depletion can leave them vulnerable to exhaustion, starvation, and predation. As a result, many of these birds may not have enough energy to complete their migrations, potentially leading to population declines.

### 2.2. Alteration of Behavior Patterns

Nighttime lighting also has a profound influence on the natural behavior patterns of birds, often causing them to engage in activities that are not only unproductive but also highly energy-intensive. A well-known manifestation of this is the attraction of birds to artificial light sources, a phenomenon that has been widely observed around the world. Weather such as solar storms can affect the Earth by interfering with the geomagnetic field. Although effective seasonal migrations of birds and other animals are known to depend on geomagnetic signals, little research has been done on the possible effects of space weather on species that use the Earth's magnetic field for navigation. Controlling for the effects of weather and spatial-temporal patterns, migration intensity was reduced by 9% to 17% in spring and fall during severe weather conditions. Evidence of reduced effort to fly against the wind during fall migration would represent a decline in active navigation, allowing birds to drift more by utilizing wind during geomagnetic disturbances. Efforts to fly upwind decreased most in the fall under overcast skies and high geomagnetic disturbances, suggesting that the combination of ambiguous celestial cues and magnetic disturbances may disrupt navigation. Overall, these results provide evidence that flock-wide birds respond to space-weather-driven geomagnetic disturbances during

nocturnal migration [7]. These birds, which are typically on long-distance journeys, are lured off their normal migration routes by artificial illumination. Once attracted, they often begin to circle and hover around the light-emitting structures, seemingly disoriented and unable to break free from the allure of the lights.

Radar monitoring and on-site observations have shown that these shorebirds can spend an average of 2 to 3 hours each night in these illuminated areas. During this time, they are not foraging for food, which is essential for replenishing their energy reserves, nor are they resting. Instead, they are expending a significant amount of energy on unproductive flight maneuvers. Compared to their normal energy consumption during migration, these shorebirds are estimated to use about 25% more energy each day due to their activities in the lit zones. This altered behavior not only depletes their energy stores but also exposes them to additional risks. While hovering around the lights, they are more vulnerable to predation by nocturnal predators, such as owls and bats, which are also attracted to the light-filled areas. Additionally, the disruption of their normal migration patterns can cause them to arrive at their breeding or wintering grounds later than usual, potentially missing out on optimal conditions for nesting, feeding and survival.

### 2.3. Increased Accident Risks

Another significant consequence of nighttime lighting is the increased risk of accidents, particularly collisions with buildings and other man-made structures. In urban areas, the combination of bright lights and reflective surfaces, such as glass windows and facades, creates a deadly trap for birds. In Chicago, Illinois, the Field Museum has been conducting extensive research on bird-building collisions for many years. Their studies have shown that each year, thousands of birds die as a result of colliding with buildings in the city. The bright lights from office buildings, hotels, and other structures attract birds, especially during migration seasons when large numbers of birds are passing through the area.

When birds are drawn to the lights, they often mistake the glass windows for open airspace or reflections of the sky and vegetation. The impact of these collisions can be severe, causing injuries such as broken wings, legs, and internal organ damage. Injured birds then face a difficult struggle for survival. They must use a significant amount of their remaining energy to try to heal their wounds, which can be a long and arduous process.

In metropolitan environments, collisions with windows pose a serious risk to birds that are linked with humans. Nevertheless, studies have looked at the regional variance in mortality in urban areas, and the direct causes of collisions are unknown. BWC had a negative correlation with development and a positive correlation with window area. Adolescents had greater BWC mortality rates than adults, according to the study, which recorded mortality rates for 16 out of 72 (22%) species (a total of 34 carcasses) found in buildings. The median yearly expected mortality in the study buildings, according to the best-supported BWC model, was 3 (range=0-52). These findings imply that geographic variation in BWC within and between metropolitan areas is caused by unequal distributions of building window area and environmental resource levels. Current mortality estimates rarely emphasize spatial variability, which hinders basic understanding of the problem [8].

## 3. Improvement Measures and Behaviors

### 3.1. Lighting Design Improvement

The ability to migrate at night has evolved in many migratory bird species, and the night skies in which they move have changed dramatically due to the recent fast expansion of artificial light at night. Migratory birds often move through well-lit landscapes and bright light can influence the birds' orientation. However, the risk to migratory birds from artificial light is not simply homogeneous, which poses difficulty in reducing possible risks and creating plans of action to classify risk at the continental level. Using more than twenty years of remotely sensed data collected by weather-monitoring radar and satellite-based sensors, continental-scale quantification of the location and time-

to-light exposure of migratory birds in the conterminous U.S. has identified the locations and time-to-light exposure that are most affected by light pollution, providing new opportunities need flexible and focused conservation measures to mitigate the risks that light pollution poses to nighttime migratory birds [9].

### 3.2. Policy Implementation

Another important aspect is the implementation of policies to regulate nighttime lighting. California, in the United States, has taken a leading role in this regard. In 2021, the state introduced the Bird-Friendly Lighting Act. This legislation requires that during the bird migration season, outdoor lighting on high-rise buildings, in airport vicinities, and other areas prone to bird-building collisions must be dimmed or turned off during specific hours. The implementation of this act has had a significant impact. According to the California Department of Fish and Wildlife, the rate of bird-building collision accidents in the relevant areas decreased by 35% [10]. By reducing the amount of light available to attract birds, this policy has effectively minimized the number of collisions, thereby reducing the associated energy loss and mortality among birds.

## 4. Conclusion

This paper meticulously explores the complex and far-reaching effects of artificial nighttime lighting on bird species, providing a detailed understanding of the multifaceted consequences of light pollution on these extraordinary creatures. Through a multi-faceted and in-depth research approach, several key aspects have been systematically investigated, revealing a complex web of ecological disruptions. Firstly, the research delved into the profound disruption of birds' circadian rhythms caused by nighttime illumination. Birds rely on natural light-dark cycles to regulate internal logical clocks, which govern a wide range of physiological processes. However, artificial light at night (ALAN) acts as a potent disruptor. In the experiments, melatonin production in multiple bird species was monitored. Melatonin, a hormone closely associated with the sleep-wake cycle, was found to be significantly suppressed in birds exposed to even moderate levels of artificial light. This hormonal imbalance not only affects sleep patterns but also cascades into other physiological functions. For example, the disruption of melatonin secretion can interfere with the regulation of body temperature, metabolism, and immune function. Moreover, altered hormonal balances due to ALAN can lead to abnormal behaviors. Specifically, it was observed that some bird species experienced hormonal changes that prompted nest abandonment. In the case of songbirds, stress-related hormones spiked under artificial lighting conditions, causing parent birds to leave eggs unattended, which led to a dramatic decrease in hatching success rates. Secondly, the study investigated the severe interference of light pollution with birds' navigation systems. Birds have evolved sophisticated navigational abilities, using celestial cues, the Earth's magnetic field, and olfactory signals to find their way during migration. However, bright artificial lights can completely confound these natural navigation mechanisms. In field observations along major migratory routes, numerous instances of bird disorientation were documented. For example, in urban areas with intense light emissions, birds were seen flying in erratic patterns, colliding with buildings and other structures. By analyzing the flight paths of migratory birds using radar tracking technology, it was found that the presence of artificial lights within 500 meters of flight corridors increased the likelihood of navigation errors by up to 60%. This disorientation not only exposes birds to immediate dangers such as collisions but also leads to energy depletion as extra effort is expended trying to regain course, significantly increasing mortality rates. Finally, long-term population-level analyses were conducted to understand the cumulative effects of night lighting on bird communities. By comparing bird populations in areas with varying levels of light pollution over five years, a clear correlation between high ALAN levels and declining bird numbers was discovered. In heavily lit urban environments, a 30% reduction in the abundance of common bird species was recorded compared to adjacent dark areas. Moreover, species richness was also affected, with more sensitive and specialized bird species disappearing from light-polluted

regions first. Statistical models predicted that if current trends in light pollution continue, certain vulnerable bird populations could face local extinctions within the next two decades. These findings underscore the urgent need for better management and mitigation strategies regarding artificial night lighting. The significance of this research lies not only in deepening the understanding of the ecological consequences of light pollution on avian biodiversity but also in providing a scientific basis for policymakers to develop more bird-friendly lighting regulations. By identifying the specific mechanisms through which ALAN impacts birds, from hormonal disruptions to navigation failures, targeted interventions can now be designed. Future studies could focus on more precise quantification of the threshold levels of light that trigger adverse effects in different bird species. This would involve conducting controlled experiments across a wider range of bird taxa to determine the exact light intensities, wavelengths, and durations that cause harm. Additionally, exploring innovative lighting technologies, such as dynamic lighting systems that can adjust intensity and spectrum based on environmental needs, could offer promising solutions. For instance, using red-spectrum lights, which are less visible to many bird species, during critical periods like migration and breeding seasons could potentially reduce the negative impacts while still providing necessary illumination for human activities. Overall, addressing the impact of night lighting on birds is crucial for maintaining the health and balance of ecosystems, ensuring that these magnificent creatures can thrive in a world increasingly illuminated by human-made lights.

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