NPS Natural Sounds & Night Skies Division Annual Synthesis of Studies on the Effects of Artificial Light at Night 2024

# Past Suggested Reading – Light

## 2023

This year’s suggested articles address ALAN impacts on human health, plant diversity, and freshwater ecosystems.[Wang et al. 2023](https://www.sciencedirect.com/science/article/abs/pii/S0269749123003238?via%3Dihub) conducted a qualitative literature review on ALAN and human health. Through the narrative, they found the biggest impact is on sleep and the indirect effects of lack of sleep. In addition, they concluded with four findings: 1) there needs to be a detailed methodology developed to deal with scale issues of outdoor nighttime lights, 2) additional research is needed on human health consequences and exposure to ALAN both indoor and outdoor, 3) further investigation with a concentration on mental health and behavior is warranted, and lastly 4) the assumption of the causal relationship between ALAN and human health needs to be backed by additional focused research. Wang et al. 2023 also review the positives associated with ALAN, such as feelings of safety which is a perception, and more research needs to be conducted. Others have also pointed out the positives of ALAN, which is by nature human-centric lighting.A new study by [Bucher et al. 2023](https://royalsocietypublishing.org/doi/10.1098/rstb.2022.0358) looked at plant diversity across different lighting regimes. The team set up 12 individual sites in an indoor facility. They established a gradient in ALAN across all 12 from no supplemental light to 30.313 lx in the most light-polluted treatment – an illuminance large as that at pavement level directly underneath a street light. The background illumination within the facility was 1.4 mlx due to interior lighting (ie technical devices). The experiment found that after planting 16 different species in each unit, the productivity decreased with increasing ALAN in the first harvest and little effect for a second harvest. There was no significant effect of ALAN on the plant species richness but the Shannon diversity declined significantly with increasing ALAN. Overall, the study concluded that plant biomass decreased in every unit measured after first harvest. In addition, they found that ALAN negatively affected diversity and some species functional traits. This study informs plant conservation with regard to light pollution.The last article by [Holker et al. 2023](https://royalsocietypublishing.org/doi/full/10.1098/rstb.2022.0360) examined freshwater ecosystems as an often overlooked area of inquiry. This is a thorough review of the literature on the effects of light pollution on freshwater wildlife and ecosystems. It presents the intensity and spectra that affect freshwater ecosystems in a clear and concise way. The specific lux are given for different species. For example, white light as low as 0.01 and 1 lux can suppress melatonin in some fish species. Remember that a full moon is 0.03 lx at zenith. The conclusion is that we need additional freshwater ecosystem research and that mitigation of both terrestrial and aquatic lighting is needed.

* Bucher, S. F., Uhde, L., Weigelt, A., Cesarz, S., Eisenhauer, N., Gebler, A., Kyba, C., Römermann, C., Shatwell, T. & Hines, J. (2023). [Artificial light at night decreases plant diversity and performance in experimental grassland communities.](https://royalsocietypublishing.org/doi/10.1098/rstb.2022.0358) Philosophical Transactions of the Royal Society B, 378(1892), 20220358. <https://doi.org/10.1098/rstb.2022.0358> **Open Access.**
* Hölker F., Jechow A., Schroer S., Tockner K., Gessner M.O. (2023). [Light pollution of freshwater ecosystems: principles, ecological impacts and remedies.](https://royalsocietypublishing.org/doi/full/10.1098/rstb.2022.0360) Phil. Trans. R. Soc. B 378: 20220360. <https://doi.org/10.1098/rstb.2022.0360> **Open Access.**
* Wang, T., Kaida, N., & Kaida, K. (2023). [Effects of outdoor artificial light at night on human health and behavior: A literature review.](https://www.sciencedirect.com/science/article/abs/pii/S0269749123003238?via%3Dihub) Environmental pollution (Barking, Essex : 1987), 323, 121321. <https://doi.org/10.1016/j.envpol.2023.121321>

## 2022

This year’s suggested articles address ALAN impacts on urban areas, marine ecosystems, and plant productivity. [Katabaro et al. (2022)](https://www.frontiersin.org/articles/10.3389/fpubh.2022.969945/full) reviewed the impact of light pollution in urban areas. They found that nocturnal species were susceptible even to weak and temporary lighting (in addition to high-intensity urban lighting). In plants, artificial lighting prolongs day length, which has downstream impacts on the entire ecosystem. ALAN also can encourage growth out of season, affect leaf on/leaf off timing, and impact plant ability to synchronize with environmental changes. Not all ALAN impacts were negative, however; the review showed that nighttime artificial light had nuanced effects on urban ecosystems and green spaces (for example, ALAN may hurt ecosystem function, but positively impact green spaces that have high plant density and a lack of natural light). [Marangoni et al. (2022)](https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.16264) examined the impacts of ALAN in marine ecosystems, filling a necessary gap in a research field that has largely focused on terrestrial effects The article reviewed 202 papers. The authors summarized ALAN effects on marine biota, seashores/coastal areas, sea turtles, intertidal zones, shallow coral reef ecosystems, and vertical aspects of oceans. This work includes a separate section on seabirds due to the mobility of the species. There were ALAN impacts to all reviewed topics, with some species and/or ecosystems more influenced by ALAN than others. The paper also discusses where additional research is needed. Lastly, the review incorporates an inclusive management strategy that presents mitigation support, conservation guidelines, and strategies for protecting dark sky environments.Finally, [Liu et al. (2022)](https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.16126) examined how ALAN affected the performance of common and rare alien and native plant species in Germany. The authors examined both direct impacts and indirect impacts (via flying insects). The study found that common plants produced more biomass than rare ones under ALAN conditions. This might lead to competitive exclusion of rare species, which could have further cascading impacts. Additionally, the alien plants benefitted more from ALAN than the native plants, potentially suggesting that ALAN increases the risk of invasive plants.

* Katabaro J.M., Yan Y., Hu T., Yu Q., & Cheng X .(2022). [A review of the effects of artificial light at night in urban areas on the ecosystem level and the remedial measures.](https://www.frontiersin.org/articles/10.3389/fpubh.2022.969945/full) Front. Public Health 10:969945. doi: 10.3389/fpubh.2022.96994. **Open Access.**
* Liu, Y., Speißer, B., Knop, E., & van Kleunen, M. (2022). [The Matthew effect: Common species become more common and rare ones become more rare in response to artificial light at night.](https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.16126) Global Change Biology, 28, 3674– 3682. <https://doi.org/10.1111/gcb.16126>. **Open Access.**
* Marangoni, L. F. B., Davies, T., Smyth, T., Rodríguez, A., Hamann, M., Duarte, C., Pendoley, K., Berge, J., Maggi, E., & Levy, O. (2022). [Impacts of artificial light at night in marine ecosystems—A review.](https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.16264) Global Change Biology, 28, 5346– 5367. <https://doi.org/10.1111/gcb.16264>. **Open Access.**

## 2021

The suggested three articles address artificial light at night (ALAN) effects on different aspects of the human-environment interaction, ranging from infectious disease, to changes in the behavior of dung beetles and migratory birds. A new study, [**Kernbach et al. 2021**](https://doi.org/10.1098/rspb.2021.0253), supports evidence that light pollution is driving infectious disease patterns. They modeled the effect of ALAN on the emergence and duration of West Nile Virus in chickens. This research supported a 2019 study that also found that ALAN increased the infection period of birds, which has the potential of increasing WNV outbreaks by 41%. Additionally, Kernbach et al. showed that ALAN can affect when and where WNV emerges. Researchers found that most cases of WNV in chickens occurred in areas of low levels of light pollution (suburban) compared to dark (natural) and brightly light (urban) areas. In a new study, [**Foster et al. (2021)**](https://doi.org/10.1016/j.cub.2021.06.038), found that light pollution changed the orientation behavior of dung beetles. The test found a collective bias in the beetles which was studied by testing during moonlit, starlit, and overcast skies in both dark and light-polluted areas. Beetles were then also examined with the addition of artificial lighting. A significant change in orientation was found, although the exact reasons for the change remain unknown. Future research may help clarify whether these behavioral changes occur due to loss of retinal dark adaptation, diversion of lunar compass orientation, or innate attraction to blue light. The last study is one of many that look at impacts of ALAN on nocturnal migratory birds. In this study, [**Gillings and Scott (2021)**](https://doi.org/10.1111/ibi.12955) found that ALAN is linked to differences in the calling behavior of migratory birds in Europe. Although lower building heights in Europe limit death by collision, ALAN still has impacts; Gillings and Scott combined audio recordings and AI to discover that calling rates were up to five times higher in brightly lit urban areas. Again, as with most studies, ALAN effects are complicated, and they cannot be certain that the change in calling behavior imposes a fitness consequence.

* Kernbach, M. E., Martin, L. B., Unnasch, T. R., Hall, R. J., Jiang, R. H., & Francis, C. D. (2021). [**Light pollution affects West Nile virus exposure risk across Florida.**](https://doi.org/10.1098/rspb.2021.0253) Proceedings of the Royal Society B, 288(1947), 20210253. **Open Access.** (Press release on study: [**https://www.usf.edu/news/2021/light-pollution-drives-increased-risk-of-west-nile-virus.aspx**](https://www.usf.edu/news/2021/light-pollution-drives-increased-risk-of-west-nile-virus.aspx))
* Foster, J. J., Tocco, C., Smolka, J., Khaldy, L., Baird, E., Byrne, M. J., Nilsson, D.E., & Dacke, M. (2021). [**Light pollution forces a change in dung beetle orientation behavior.**](https://doi.org/10.1016/j.cub.2021.06.038) Current Biology, 31(17), 3935-3942. **Open Access.** (Press release on study: [**https://www.sciencedaily.com/releases/2021/07/210729183629.htm**](https://www.sciencedaily.com/releases/2021/07/210729183629.htm))
* Gillings, S., & Scott, C. (2021). [**Nocturnal flight calling behaviour of thrushes in relation to artificial light at night.**](https://doi.org/10.1111/ibi.12955) Ibis, 163(4), 1379-1393.

## 2020

A meta-analysis of the impacts of light pollution on animals was published this year ([Sanders et al. 2020](https://www.nature.com/articles/s41559-020-01322-x)). Previous studies have been more focused on a specific species, local community, or area. This paper takes an approach that is more ecological and holistic review approach, a more ecological. They classified 126 publications with hundreds of observations from the peer-reviewed literature. The five major response categories were: organismal physiology; seasonal phenology; life history traits; daily activity patterns; and population/community. The authors used these classes to focus on ecosystem function. The results of this article suggest there are significant implications for the mitigation of the effects of ALAN on the natural environment. Another paper of interest was focused on insects. The [Grenis and Murphy (2019)](https://onlinelibrary.wiley.com/doi/full/10.1111/1744-7917.12574) paper entitled “Direct and indirect effects of light pollution on the performance of an herbivorous insect” their findings indicate that light pollution can alter plant–insect interactions and may have important community-wide consequences. Impacts on insects is vital for ecosystem function so this paper is a good introduction to the effects of light pollution on insects as is the last suggested reading by [Owens et al. (2020)](https://www.sciencedirect.com/science/article/abs/pii/S0006320719307797). This paper examines light pollution (ALAN) as a driver of insect declines. A stronger recognition of the ways in which ALAN affects insects can help conservationists reduce or eliminate one of the major drivers of insect declines. An important concept is that ALAN is unique among anthropogenic habitat disturbances and anthropogenic pollutants in that it is easy to mitigate and leaves behind no residual effects.

* Sanders, D., Frago, E., Kehoe, R., Patterson, C. and Gaston, K.J., 2021. [A meta-analysis of biological impacts of artificial light at night.](https://www.nature.com/articles/s41559-020-01322-x) Nature Ecology & Evolution, 5(1), pp.74-81.
* Grenis, K. and Murphy, S.M., 2019. [Direct and indirect effects of light pollution on the performance of an herbivorous insect.](https://onlinelibrary.wiley.com/doi/full/10.1111/1744-7917.12574) Insect science, 26(4), pp.770-776.
* Owens, A. C., Cochard, P., Durrant, J., Farnworth, B., Perkin, E. K., & Seymoure, B. (2020). [Light pollution is a driver of insect declines.](https://www.sciencedirect.com/science/article/abs/pii/S0006320719307797) Biological Conservation, 241, 108259.