DarkSky INTERNATIONAL

Light Pollution: Challenges and Responses for Monitoring

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Scientific Advice for Policy-Makers

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Introduction

This document encapsulates the outcomes of the Light Pollution Meeting convened in Granada during the Spanish Presidency of the European Council from 14-15 November 2023. It delineates shared perspectives and considerations regarding the imperative to confront light pollution at the European Union (EU) level through the formulation of policies and legislation. Additionally, it addresses methodologies and approaches for the measurement and monitoring of light pollution.

The principal objective of formulating the manifesto is to instigate a political discourse on the escalating concern of light pollution and to facilitate the adoption of appropriate measures aimed at mitigating the adverse impacts of light pollution on the night sky, the environment, human health, and energy efficiency.

Ecosystems have developed with natural patterns of daylight, darkness, or twilight. Light pollution can disrupt these patterns altering physiology, behaviour, orientation, organism fitness, food web interactions, and biotope connectivity. Environmental protection laws do not address the adverse effects of artificial light at night on biodiversity adequately.

To achieve global goals and targets aiming to protect and restore nature for current and future generations, the nighttime environment cannot be forgotten and must be protected.

Participants concurred on the imperative need for urgent action to address significant changes and ensure the formulation of a robust policy for the protection of the night.

List of signatures (see annex document).

Disclaimer: Participants in this document are not acting as representatives of their respective institutions, except where explicitly stated.

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Manifesto for Tackling Light Pollution & Proposing EU Light Pollution Monitoring

The manifesto was adopted by the attendees at the Meeting on Light Pollution: Challenges and Responses for Monitoring organized by the Ministry of Science and Innovation during the Spanish Presidency at the EU Council on 14-15 November 2023.

This manifesto comprehensively addresses the multifaceted consequences of light pollution and underscores the imperative for cohesive and effective measures to address its impacts. The manifesto was developed and adopted to bring the attention of the EU governmental entities, including the EU Commission and the EU Parliament, to the issue of light pollution, and provide pathways for mitigation, measurement, monitoring and reduction of light pollution on the territory of the European Union (EU). Additionally, this document is adopted to enhance awareness of light pollution and its impacts at the EU level.

Preamble

Acknowledging the essential role of natural day and night cycles in facilitating normal biological functioning across all living organisms, including in promoting sustainability, well-being, and enhancing the overall quality of life of humans and species. The growing issue of light pollution, which transcends geographical boundaries, poses a significant environmental challenge impacting all living beings and leads to the fragmentation of living spaces for both species and humans,

Recalling UNEP/CMS/Resolution 13.5 on Light pollution guidelines for wildlife (2020), UNEP/CMS/Decision 12.17 on Marine Turtles (2020), EUROBATS Resolution 8.6 on Bats and Light Pollution and its Guidelines for consideration of bats in lighting projects (2018), Declaration in Defense of the Night Sky and the Right to Starlight (2007), Brno Appeal to reduce light pollution in Europe (2022), and other international documents, which recognised the importance of the natural nocturnal conditions for diverse species, the normal functioning of ecosystems, the preservation of cultural heritage, overall well-being, as well as highlighted the negative environmental impacts of light pollution,

Supporting the implementation of the Kunming-Montreal Global Biodiversity Framework 2022 within the EU which aims to halt and reverse nature loss and sets global targets to be achieved by 2030, including reduction of pollution risks and negative impacts of pollution from all sources by 2030 to levels that are not harmful to biodiversity and ecosystems,

Acknowledging that artificial light at night serves as a valuable resource contributing to the enhancement of well-being in diverse dimensions, while concurrently recognizing that artificial light constitutes a form of pollution that contradicts endeavours aimed at environmental protection,

Considering that nighttime activities constitute 50% of overall environmental functioning and encompass all living organisms, especially more than 70% of species of both flora and fauna exclusively exhibiting nocturnal behaviour, including at least 51% of threatened species,

Highlighting that the existing EU environmental policy and legislation primarily concentrate on daytime protection, the absence of preservation of the nighttime environment diminishes the overall environmental protection efforts,

Emphasizing the significant increase in both the quantity and distribution of light at night, resulting in the pervasive issue of light pollution, which grows significantly at least 2% globally per year, and 11% on a green light between 2012 to 2017 and 24% on a blue light on the same period on the EU,

Noting that light pollution has been empirically shown to have detrimental effects on human health, environmental protection[1], biodiversity conservation, habitat protection (such as habitat fragmentation), protection of pollinators, and energy consumption, and contributes to climate change, thereby exerting broader impacts on the overall quality of life on the Earth,

[1] IUCN Congress 2020. 084 - Taking action to reduce light pollution.

Alarmed that light pollution constitutes a form of environmental pollution that markedly influences and contributes to the escalation of other forms of pollution, including air, water, and soil pollution,

Emphasizing that the monitoring and measurement of light pollution stand to yield significant benefits, not only in the realm of environmental protection but also in synergistic contributions to the monitoring of other forms of pollution; and highlighting that the data obtained holds the potential for multifaceted reuse, extending to purposes such as the analysis of population density,

Fully aware that more than approximately 99% of artificial light at night is lost or ends up impacting the environment, representing more than 38 TWh and 6300 M€ per year before the energy crisis of 2022[2],

Concerned that the current EU environmental regulatory framework does not specifically include light as a pollutant nor indicate the need to address its impacts,

Referring to the prevailing EU environmental and energy policies and legislation, including the EU Green Deal and its integral components such as the Zero Pollution Plan, the EU Biodiversity Strategy 2030, the New Deal for Pollinators, and the REPowerEU plan, which set ambitious targets related to environmental protection, as well as Habitats Directive 92/43/EEC, Water Framework Directive 2000/60/EC, Strategic Environmental Assessment Directive 2001/42/EC, Marine Strategy Framework Directive 2008/56/EC, Wild Birds Directive 2009/147/EC, Environmental Impact Assessment Directive 2011/92/EU, and the forthcoming Nature Restoration Law, which impose obligations to mitigate environmental stressors,

Referring to the 8th Environment Action Program[3], which among several priority objectives indicates the need to achieve a toxic-free environment, including in relation to light pollution,

Recognizing the imperative nature of achieving the proposed targets and adhering to the legally mandated obligations outlined in the EU legislation, underscoring the EU's dedication to protecting the environment and fostering sustainable development,

Acknowledging that the European Union (EU), as the coordinating entity, assumes responsibility for harmonizing and facilitating joint action among all EU member states in pursuit of common environmental goals,

Recalling the European Parliament resolution of 9 June 2021 on the EU Biodiversity Strategy for 2030: Bringing nature back into our lives (2020/2273(INI))[4], and acknowledging both past and ongoing EU initiatives, which urged the European Commission to take proactive measures in addressing the issue of light pollution,

Emphasizing that several EU member states have taken proactive measures to reduce light pollution levels and mitigate its impacts by the adoption of policy and legal documents,

Calling the EU Commission and the member states to take immediate action to combat light pollution, assess the current magnitude of light pollution within the territory of the EU, introduce permanent monitoring of light pollution, and propose and adopt the following measures:

1. **Recognize light as an environmental pollutant** and stressor for biodiversity, and include light pollution into the current EU environmental regulatory framework.
2. Following the EU Parliament proposal articulated by the resolution of 9 June 2021[5], **include ambitious targets to reduce light pollution** in the EU Biodiversity Strategy and other relevant policies to promote the achievement of international and European goals to protect the environment and biodiversity.
3. **Include light** as an integral and mandatory **part of European Environmental Monitoring (EEM)** - periodic and/or continued measuring, evaluating, and determining environmental parameters and/or

[2] Sanchez de Miguel A. (2015) Spatial, Temporal and Spectral Variation of Light Pollution and its Sources: Methodology and Results; available online: https://zenodo.org/records/1289933; Sánchez de Miguel, A.; Bennie, J.; Rosenfeld, E.; Dzurjak, S.; Gaston, K.J. First Estimation of Global Trends in Nocturnal Power Emissions Reveals Acceleration of Light Pollution. Remote Sens. 2021, 13, 3311. https://doi.org/10.3390/rs13163311; Sánchez de Miguel, A., Bennie, J., Rosenfeld, E., Dzurjak, S., & Gaston, K. J. (2022). Environmental risks from artificial nighttime lighting widespread and increasing across Europe. Science advances, 8(37), eabl6891. https://doi.org/10.1126/sciadv.abl6891

[3] Decision (EU) 2022/591 of the European Parliament and of the Council of 6 April 2022 on a General Union Environment Action Programme to 2030.

[4] European Parliament resolution of 9 June 2021 on the EU Biodiversity Strategy for 2030: Bringing nature back into our lives (2020/2273(INI)).

[5] Ibid.

pollution levels in order to prevent negative and damaging effects to the environment[6], as well as a part of the Environmental Impact Assessment (EIA) within the respected Member states.

4. **Implement a monitoring network** within the EU and member states without hesitation driven by the availability of solutions and technological readiness for both ground-based and satellite light pollution measurements, and support collaboration between different European institutions for efficient action to measure and reduce light pollution levels in the territory of the EU.
5. **Initiate the development and dissemination of** a comprehensive **toolkit for light pollution mitigation**, intended for widespread sharing among Member States, fostering adoption at both national and local levels to effectively regulate and control light emissions.
6. **Ensuring accurate fulfilment of obligations** set by the **Natura 2000 legal regime**, including the obligation 'to avoid the deterioration of natural habitats and the habitats of species as well as disturbance of the species', enhance the protection of existing and future Natura 2000 areas, while ensuring ecological connectivity between them, by minimizing artificial illumination within and surrounding areas, thereby establishing and preserving dark corridors.
7. **Promote openness, transparency, and accessibility of data concerning lighting** and light pollution levels, fostering the free exchange of information within and between Member States, and prioritize public access to environmental monitoring data, ensuring a collaborative and informed approach to addressing light pollution.
8. **Allocate funding** and offer support for **education** in the field of **lighting and light pollution monitoring**, and establish increased funding opportunities for initiatives dedicated to combating light pollution and its impacts, thereby enhancing the capacity of these efforts.
9. **Initiate awareness-raising campaigns** on light pollution mitigation, and advocate for interdisciplinary engagement to develop science-based policies and measures aimed at reducing the impacts of light pollution.
10. Consider and **include light pollution mitigation measures** adopted within international frameworks, such as UNEP.

[6] Official website of the European Environmental Agency (EEA). Definition of environmental monitoring.

Annex. Technical Clarifications and Additional Explanations

To support the adoption and implementation of the manifesto, it is important to include specific technical details related to light pollution monitoring and measurement techniques. Additionally, it is essential to clarify the data sources employed to support the manifesto's argumentation.

The primary objective of monitoring systems should be to control the overall emissions across different bands and to maintain natural conditions. This is crucial for the conservation of the natural landscape and the ecological integrity of our planet. In the case of natural protected areas, such as Natura 2000 areas, preserving the landscape and connectivity is vital, and can be achieved by, inter alia, establishing dark corridors to facilitate species migration.

While most prevalent measurement systems offer a general understanding of the magnitude of light pollution, the available techniques are fully capable of meeting environmental goals. However, unlocking their potential requires significant funding from governments at all levels. Current technologies encompass multispectral photometers, cameras, on-orbit data, and comprehensive inventories. The primary challenge lies in securing funding to deploy these systems extensively. Importantly, the EU has taken significant steps to fund various projects in light pollution mitigation, such as Stars4ALL (2016-2019), Pirineos la Nuit (2017-2022), ACTION (2019-2022) Erasmus + Starlight (2022-2024), Interreg Dynamic Light (2016-2019), Interreg: Night Light (2017-2021), Interreg NorthSea: KID - Keep it Dark (2023-2024), Interreg NorthSea: Darker Sky (2023-2026), and the upcoming sister projects funded under the EU Horizon 2023 Programme (call "Impact of Light and Noise Pollution on Biodiversity") (2024-2028), which already brought and will bring additional knowledge and solutions for reduction of light pollution and its impacts.

In addition to further research and funding, critical needs include resources from environmental agencies for deploying measurement networks and campaigns, political determination to enhance current lighting inventories, and investment from the European Space Agency and EUSPA for a dedicated nighttime remote sensing satellite. This would complement existing platforms, as none have been specifically designed to monitor light pollution.

The integration of manual lighting inventories with photometers and the broader perspective offered by satellite imagery is fundamental for a comprehensive understanding and effective management of light pollution.

A holistic approach to measuring light pollution should involve both ground-based and satellite measurements across various spectral bands. Additionally, detailed lighting inventories must offer essential spectral data and information on the distribution of light emissions. Access to this inventory data should be open and shared openly with the public to ensure transparency regarding light pollution levels. High-quality inventories have the potential to serve as a robust solution to the challenge of light pollution.

The foundation of the manifesto rests on information sourced from established and published research, as well as from adopted legal and policy documents. Scientific sources used for this manifesto include, inter alia:

Sánchez de Miguel, A., Bennie, J., Rosenfeld, E., Dzurjak, S., & Gaston, K. J. (2021). First estimation of global trends in nocturnal power emissions reveals acceleration of light pollution. Remote Sensing, 13(16), 3311; available online: https://www.mdpi.com/2072-4292/13/16/3311

Sánchez de Miguel, A. (2015). Spatial, Temporal and Spectral Variation of the Light Pollution and its Sources: Methodology and Results. Universidad Complutense de Madrid; available online: https://zenodo.org/records/1289933

Sánchez de Miguel, A., Bennie, J., Rosenfeld, E., Dzurjak, S., & Gaston, K. J. (2022). Environmental risks from artificial nighttime lighting widespread and increasing across Europe. Science Advances, 8(37), eabl6891; available online: https://www.science.org/doi/10.1126/sciadv.abl6891

Kyba, C. C., Kuester, T., Sánchez de Miguel, A., Baugh, K., Jechow, A., Hölker, F., ... & Guanter, L. (2017). Artificially lit surface of Earth at night increasing in radiance and extent. Science advances, 3(11), e1701528; available online: https://www.science.org/doi/10.1126/sciadv.1701528

Sánchez de Miguel, A., Aubé, M., Zamorano, J., Kocifaj, M., Roby, J., & Tapia, C. (2017). Sky Quality Meter measurements in a colour-changing world. Monthly Notices of the Royal Astronomical Society, 467(3), 2966-2979; available online: https://academic.oup.com/mnras/article/467/3/2966/3061573

Sánchez de Miguel, A., Kyba, C. C., Aubé, M., Zamorano, J., Cardiel, N., Tapia, C., ... & Gaston, K. J. (2019). Colour remote sensing of the impact of artificial light at night (I): The potential of the International Space Station and other DSLR-based platforms. Remote sensing of environment, 224, 92-103; available online: https://www.sciencedirect.com/science/article/pii/S0034425719300410

Bará, S., & Falchi, F. (2023). Artificial light at night: a global disruptor of the night-time environment. Philosophical Transactions of the Royal Society B, 378(1892), 20220352; available online: https://royalsocietypublishing.org/doi/full/10.1098/rstb.2022.0352

Yakushina Y. (2022) The response to the Bonn Convention on Migratory Species to light pollution, 2022 IOP Conf. Ser.: Earth Environ. Sci. 1099 012048; available online: https://iopscience.iop.org/article/10.1088/1755-1315/1099/1/012048

IUCN (2021) 084 - Taking action to reduce light pollution; available online: https://www.iucncongress2020.org/motion/084#:~:text=8.,measures%20to%20reduce%20light%20pollution