

Visual Quality in Low-Light Environments

Effects of White, Amber, and Red Lighting on Perception and Light Pollution Reduction

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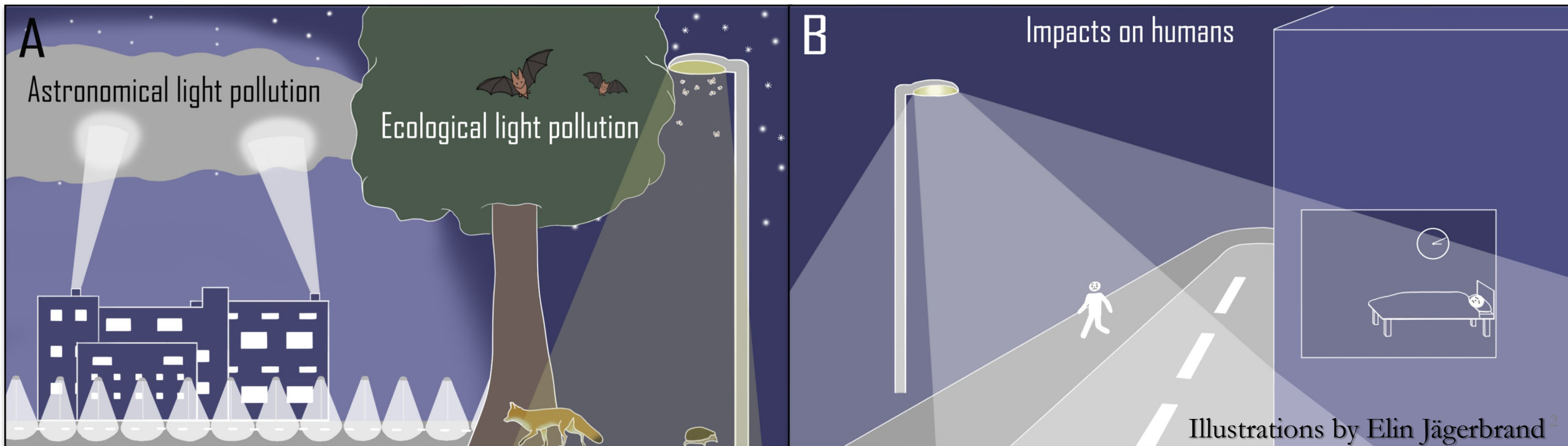
Light Pollution

- sum total of all adverse effects of artificial light*

Atmospheric and astronomical light pollution

Ecological light pollution

Impacts on humans:
I. behaviour and physiology,
II. obtrusive light



Illustrations by Elin Jägerbrand²

*CIE S 017:2020 ILV: International Lighting Vocabulary, 2nd edition.

Jägerbrand AK, Nilsson Tengelin M, Durmus D. An overview of the adverse effects of outdoor light at night and the research methods used in different areas. Proceedings of the 14th European Lighting Conference, Lux Europa 2022, Prague, Czech Republic, 20–24 September 2022, pp. 130–137.

Motivation

Adverse effects have been shown for light pollution in

- Humans (Durmus et al., 2022)
- Numerous species and ecosystems (Jägerbrand & Spoelstra, 2023)

Durmus, D., Tengelin, M. N., & Jägerbrand, A. (2022). Investigating the methods and health outcomes of research studies on light pollution and human physiology and behaviour: a systematic review. In 2021 Joint Conference-11th International Conference on Energy Efficiency in Domestic Appliances and Lighting & 17th International Symposium on the Science and Technology of Lighting (EEDAL/LS: 17) (pp. 1-6). IEEE.

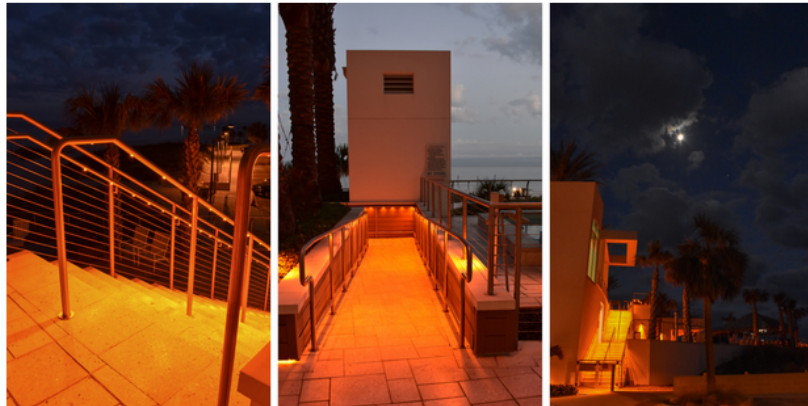
Jägerbrand & Spoelstra (2023) Effects of anthropogenic light on species and ecosystems. *Science* 380 (6650) 1125-1130.



Amber Light: The Nostalgia

Integrating Lighting with Wildlife

The need for "Turtle-Friendly Amber" lights has been well-documented and well-deployed. Up and down coasts home to sea turtle breeding grounds, great steps have been made to ensure that the hatchlings are protected from light pollution. To be Wildlife-Certified, the LED must produce a spectral distribution between the 590-610 nanometer wavelength. If you've ever seen this in the field, you've no doubt noted its deep reddish-orange hue, and generally dim appearance.



Turtle-Friendly Amber KLIK LEDpods™ at Opal Sands Resort in Clearwater Beach, FL, USA

Beyond turtles, a movement is underway to more gently interface the human

Importance of Amber LED Street Light

Amber LED street light seems to take the crown as the new lighting technology is highly revered for bringing back the moody urban glow. Before moving forward, let's have a brief look into the origination of LEDs.

Lighting has long been added to the outdoor environment. Early street lighting systems were largely driven by brightness for smooth traffic flow, convenience, and safety. For years, the yellowish high-pressure sodium lights illuminated the streets before it was realized that they were increasingly becoming the source of environmental pollution besides increasing the electricity cost.

Engineers started exploring the cost-effective and sustainable choice for road lighting. The emergence of white LED street lights was a stark counterpart to the sodium lights with the hypothesis that street lighting technology had come of age. Let's see how cities leveraged white LED street lights.



Red Light: The New Frontier

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AccessFixtures High-Performance Lighting Solutions Shop Now Search

LED Wildlife Friendly Lighting
Bollard Lights – Wall Packs – Flood Lights



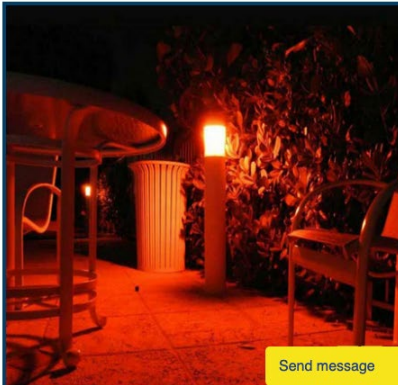
Wildlife Lighting - Illuminate Roads, Walkways, and Parking While Minimizing the Effect of Lighting on Wildlife Shop Turtle & Wildlife Friendly

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Wildlife lighting from Access Fixtures features LEDs that emit light in a wavelength safe for wildlife in coastal areas, roads, walkways, and parking lots. These LED fixtures safely illuminate areas while also protecting and minimizing the effect of light pollution on our wildlife.

While having outdoor lights is often mandatory for human visibility and safety, artificially manufactured light can be a severe threat to wildlife. For hundreds of years, regular lighting has had a damaging effect on wildlife by disturbing their natural behavior. Light pollution in the form of standard lighting negatively impacts these animals by essentially turning their nights into days, disrupting their circadian rhythms. These lights can attract wildlife such as turtles and frogs to areas considered harmful, such as roadways and commercial locations. The light emitted from Access Fixtures wildlife friendly lighting is almost invisible to these animals; they do not see the light and therefore are not drawn toward buildings, bollards, and parking lots. LED wildlife lighting is available in bollards, wall packs, floods, garage lighters, and more.

A study carried out by the Florida Fish and Wildlife Research Institute explains that "sea turtle populations have [suffered declines worldwide](#), and their recovery largely depends upon



Send message

<https://www.accessfixtures.com/led-wildlife-lighting/>

Red lighting could rewild night skies plagued by light pollution

Boise State Public Radio News | By [Sasa Woodruff](#)

Published December 16, 2022 at 3:59 AM MST



Hunter Cole / Boise State University

In Grand Teton National Park, biology professor Jesse Barber is testing how red street lights might mitigate the effects of light pollution on wildlife, such as moths and bats.

<https://www.boisestatepublicradio.org/news/2022-12-16/red-lighting-could-rewild-night-skies-plagued-by-light-pollution>

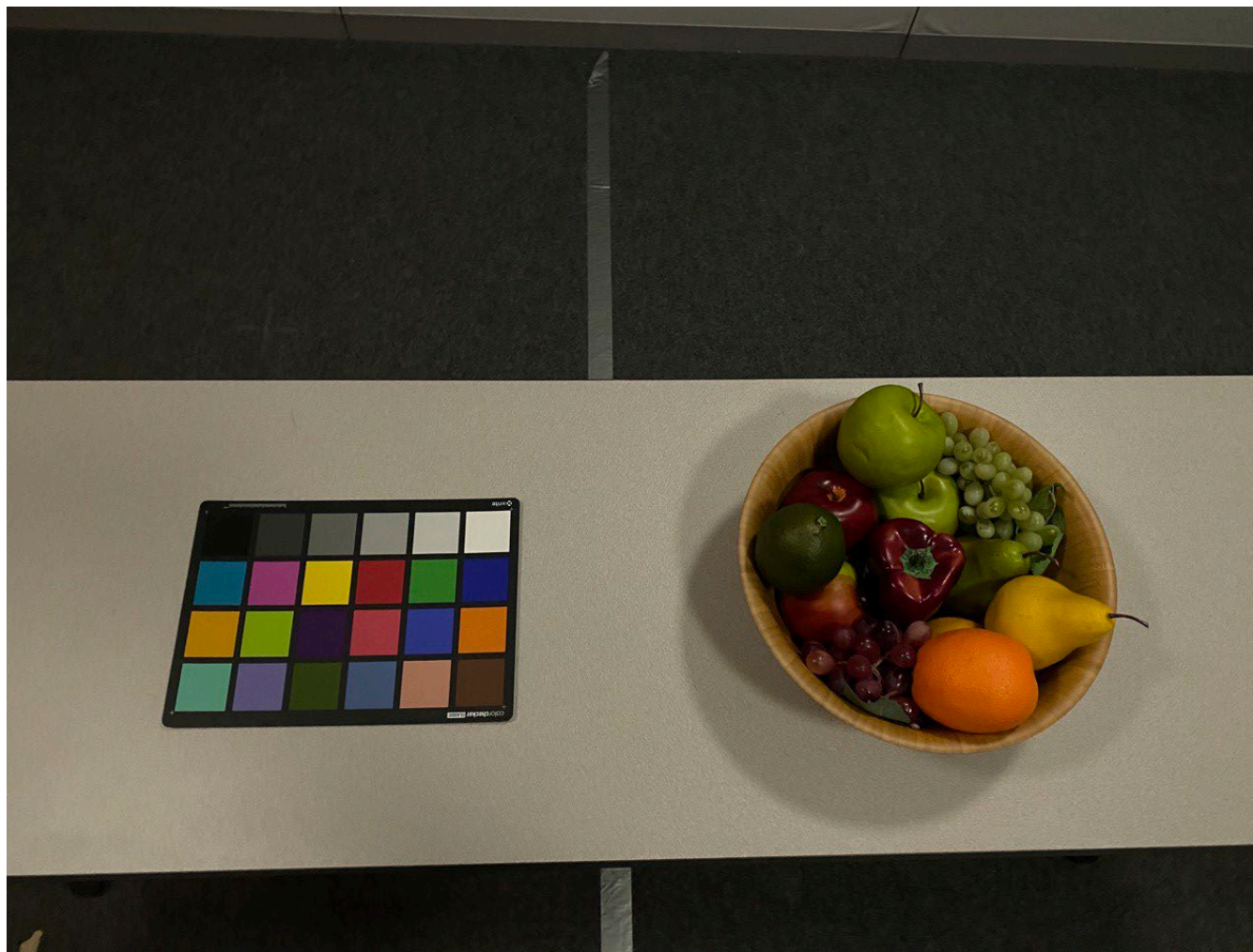
Research Question(s)

- What is the trade-off between visual quality and light pollution mitigation strategies?
- Does the visual quality suffer greatly under narrowband chromatic lights compared to white light?

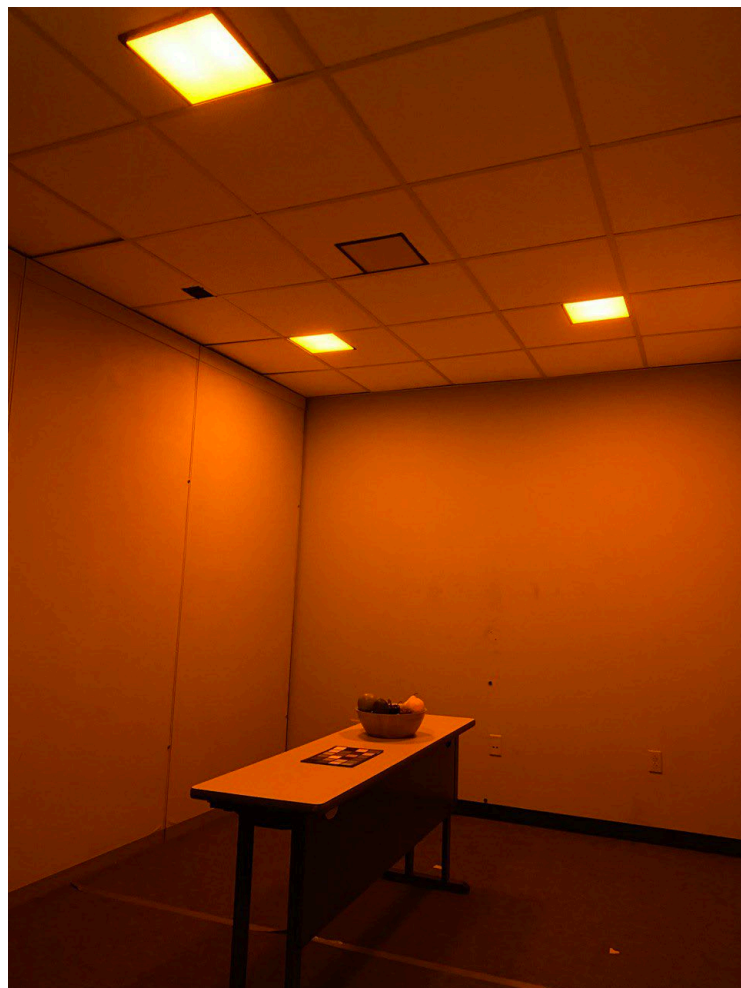
Lighting Conditions

	1	2	3	4	5	6	7
	White	White	White	White	White	Amber	Red
$E_{v,ver}$ (lx) @4 ft	26.8	14.7	7.6	4.3	1.7	7.5	7.8
$E_{v,hor}$ (lx) @floor	33	17	8	4.4	1.0	8.8	9
$E_{v,hor}$ (lx) @table	45.4	23.3	11.8	2.5	1.4	11.8	12.73
E_{mel} (W/m ²)	28.2	10.12	5.294	3.1	1.27	0.34	0.316
E_e (W/m ²)	0.126	0.064	0.031	0.006	0.003	0.024	0.071
R_f	68	69	68	67	62	-	-
R_g	93	93	93	87	79	-	-
T_{cp} (K)	4563	4563	4506	5052	4795	-	-

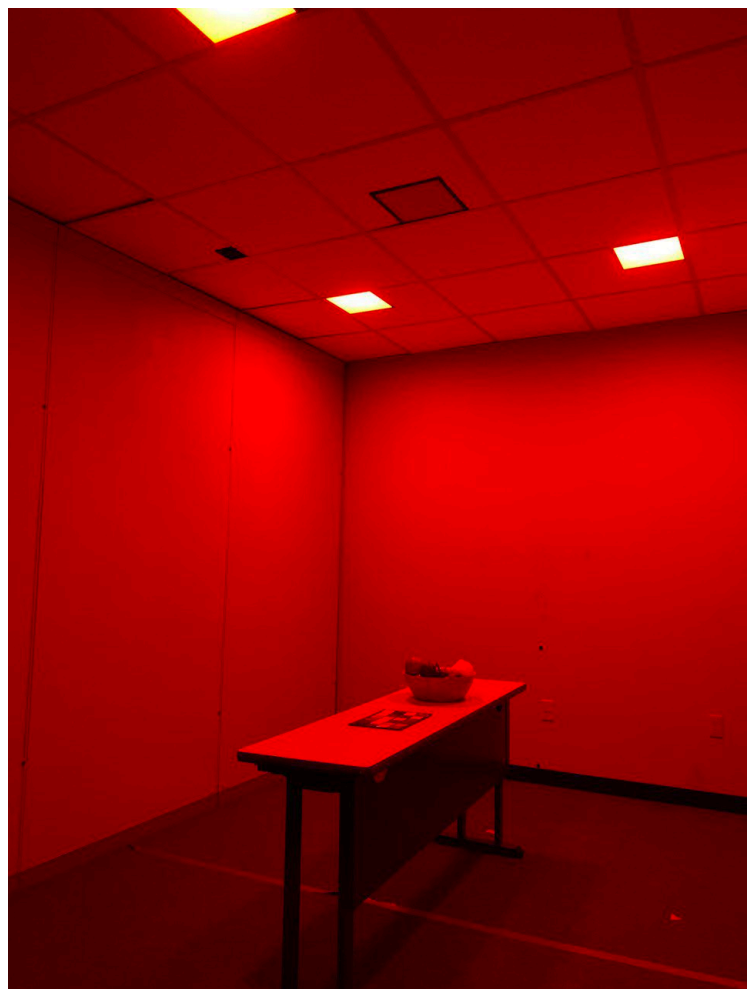
Lighting Conditions



Lighting Conditions



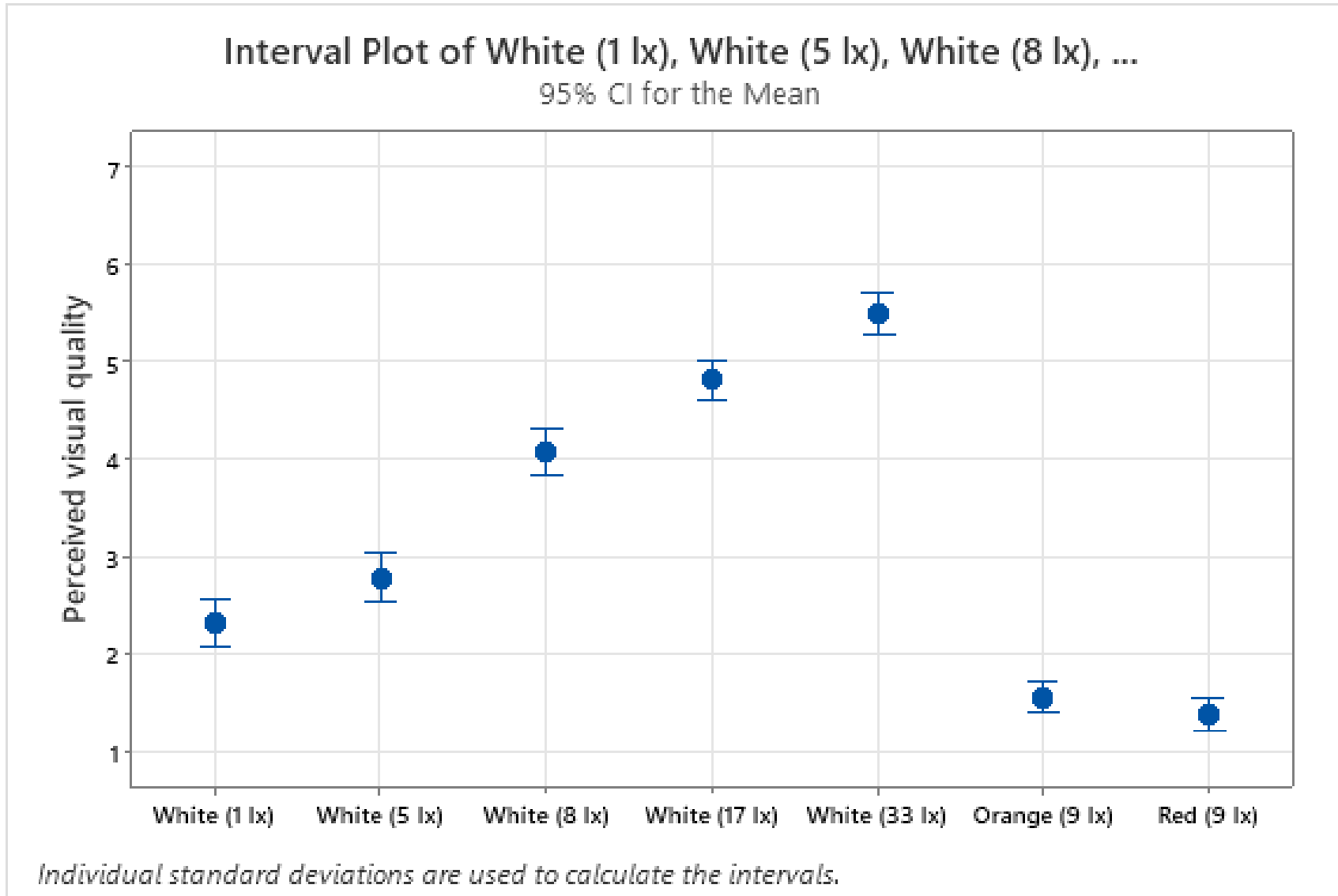
Lighting Conditions



Participants and Protocol

- 29 participants (14 female, 15 male)
- Ages between 19-25
- Each lighting condition repeated 3 times
- Trials shown in a randomized order
- Objects: Macbeth ColorChecker samples, artificial fruits and veggies
- Rate the visual quality of the objects (e.g., can you identify all the objects?)
(**extremely poor**) 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 (**extremely good**)

Results



Summary

- Findings reveal a significant impact on visual quality, with objects perceived most poorly under red and amber lighting (9 lx), followed by very dim white lighting at 1 lx.
- Illuminance-dependent relationship was observed, indicating that as lighting levels increased, visual quality improved.
- Intricate interplay between light source chromaticity, illuminance, and visual quality in low-light settings

Epilogue

- Illuminance (therefore irradiance) increase to offset poor visual performance should be studied.
- Caution is needed for spectral tuning of LAN as a mitigation strategy. Highly optimized lighting can be an ecological trap for other species.
- Energy efficiency of red light



Questions?

