Minimizing Skyglow

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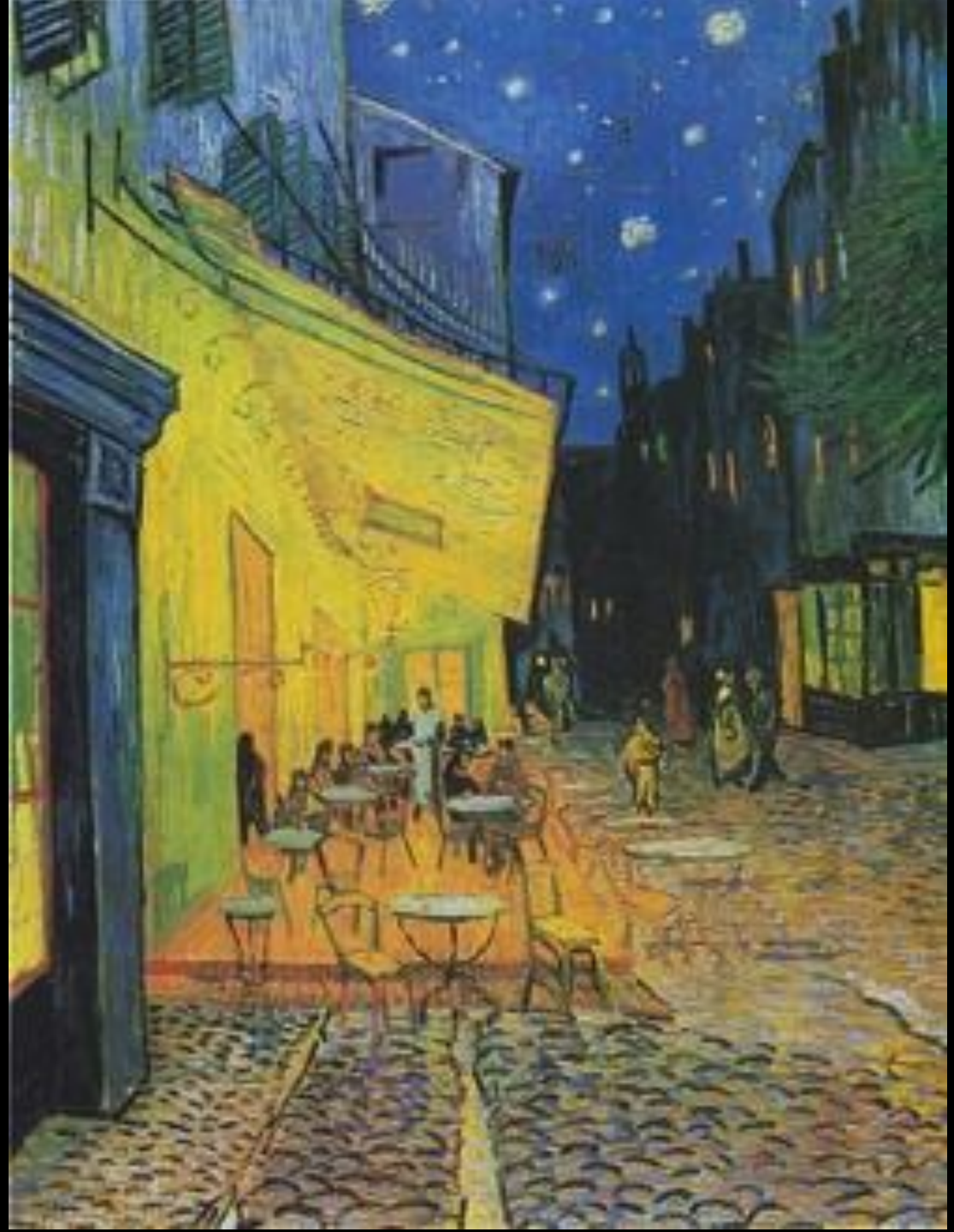
Starry night over the Rhône, 1888
Vincent van Gogh, Musée d'Orsay



Terrace of the café on the Place du Forum in Arles in the evening, 1888
Vincent van Gogh, Kröller-Müller Museum

Overcast skies

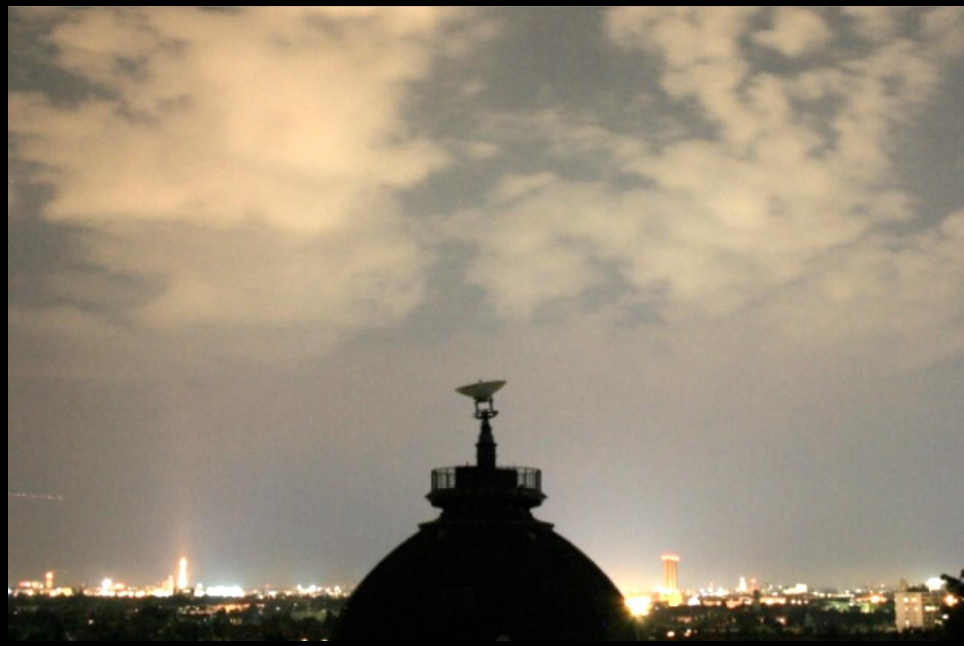
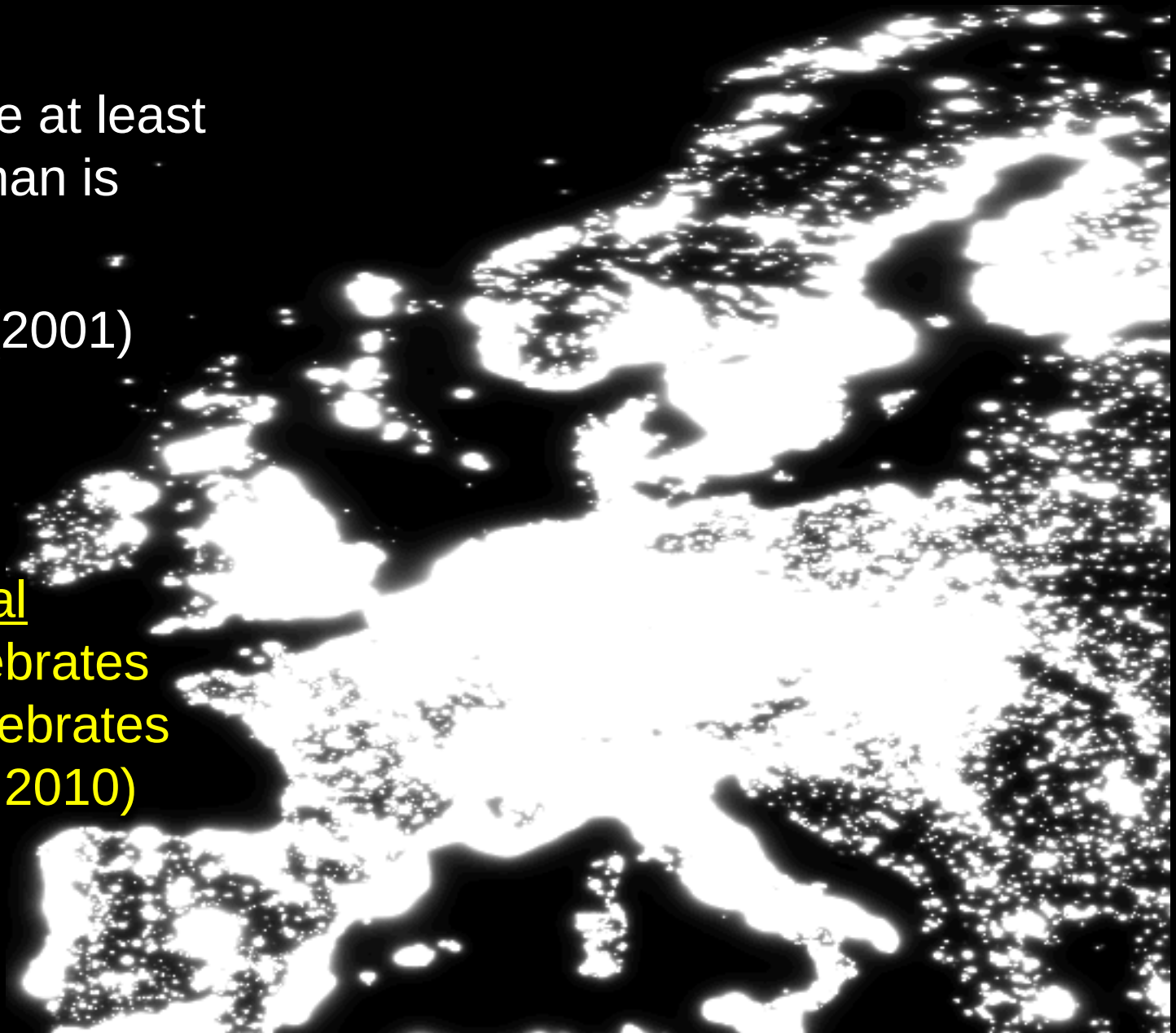


Image: Zoltan Kolláth

Skyglow in Europe

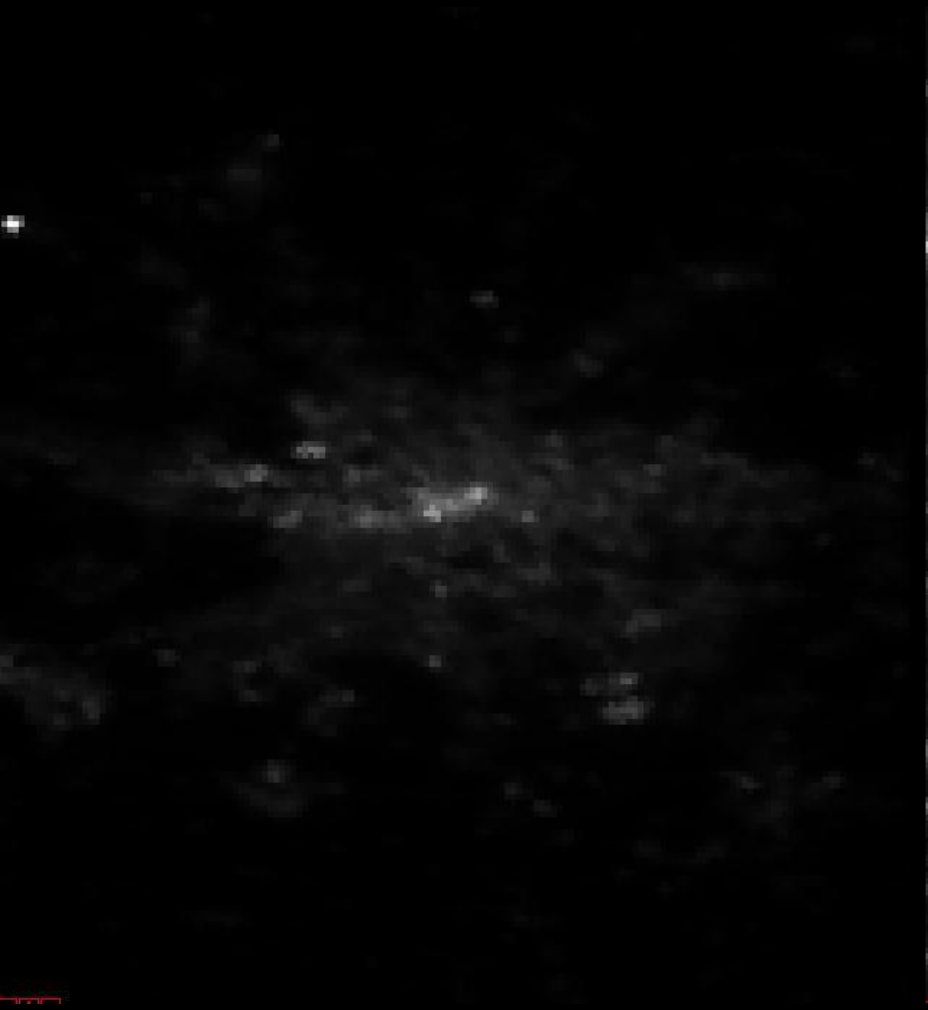
White areas are at least 35% brighter than is natural

Cinzano et al (2001)

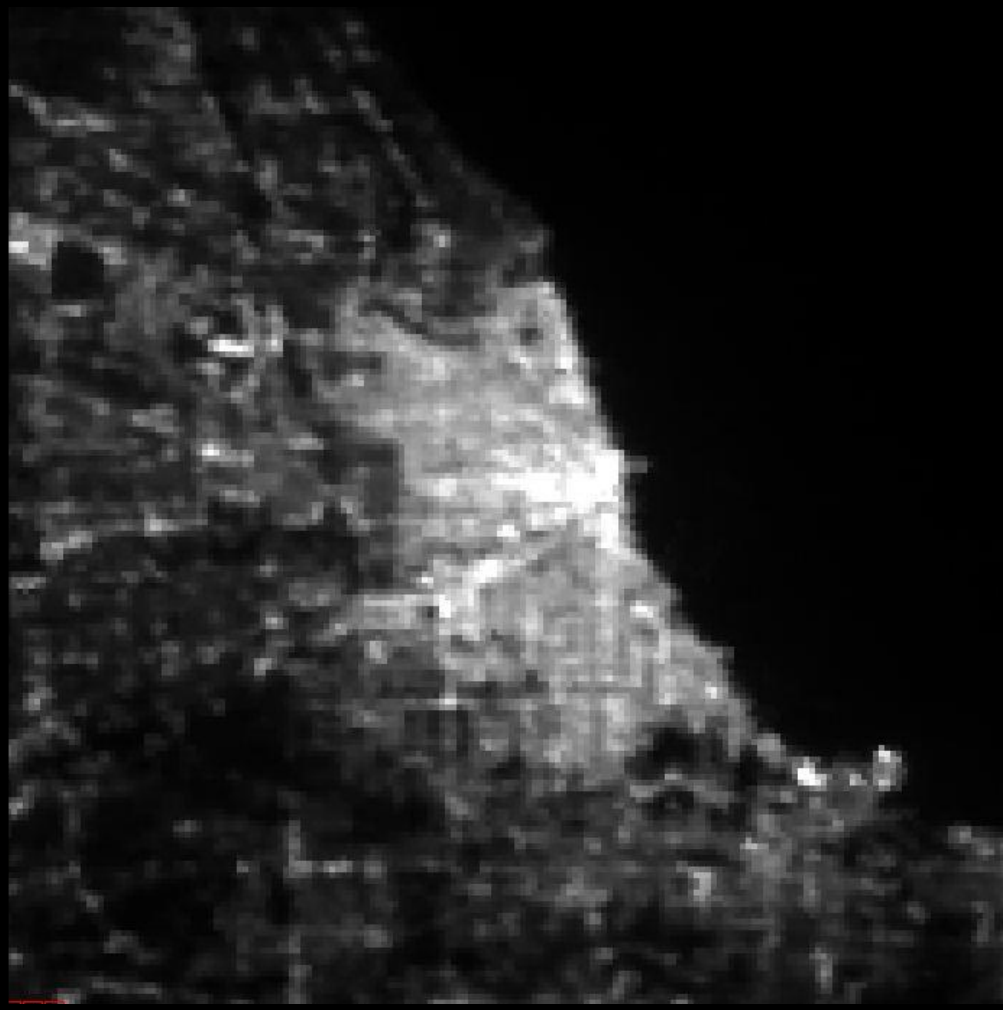


Nocturnal
~30% of vertebrates
>60% of invertebrates
(Hölker et al. 2010)

Berlin vs Chicago
1:30 in the morning

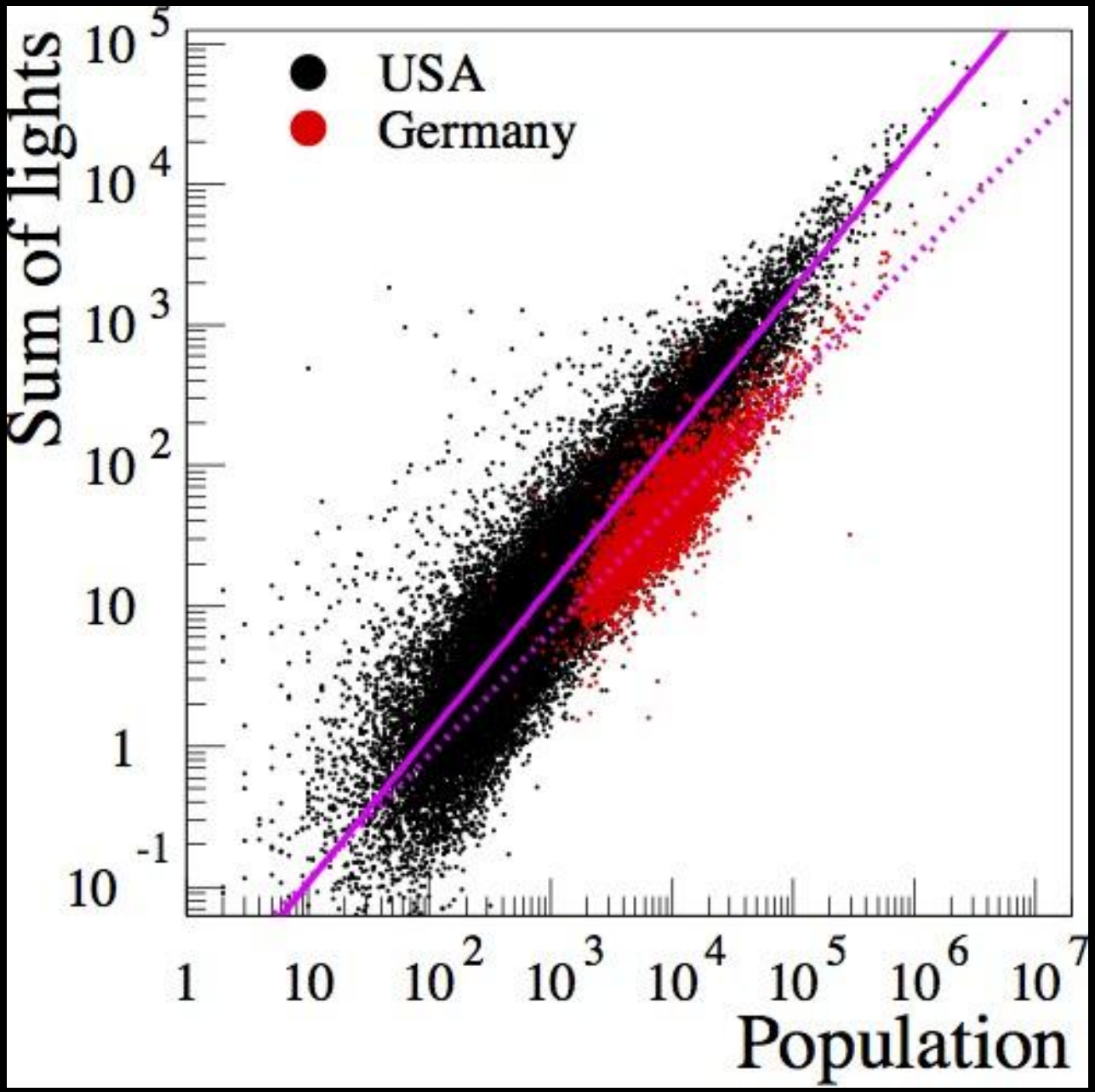


3.5 Million people



2.7 Million people (9.5M metro)

Comparison of USA and DE



Kyba et al. Remote Sensing (2015)

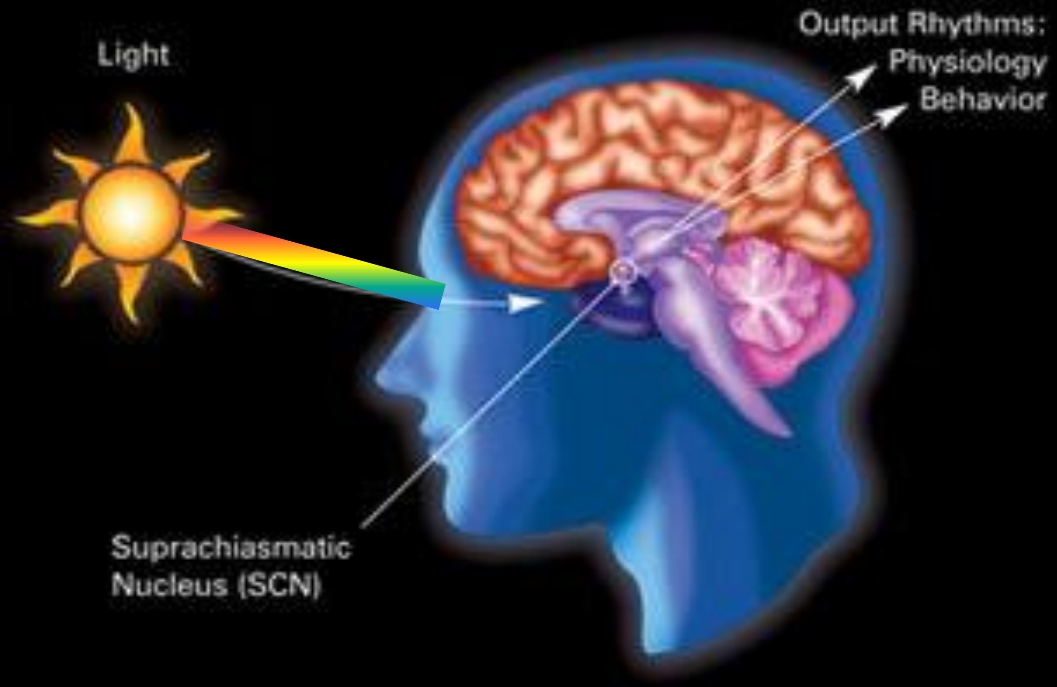
Pollution

- Chemical pollution
- Greenhouse gases
- Plastic
- Radioactivity
- Land use

Pollution

- Chemical pollution
- Greenhouse gases
- Plastic
- Radioisotopes
- Land use / impermeable surfaces
- **Artificial light at night**

Light is not neutral

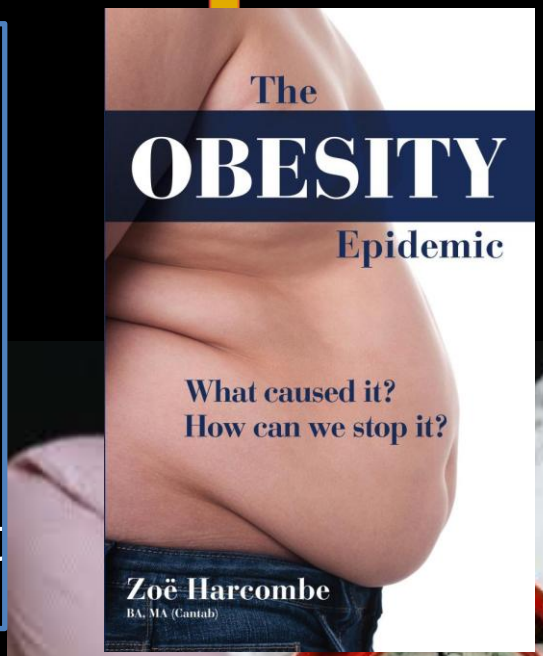


National Institute of General Medical Sciences - Circadian Rhythms Fact Sheet
https://commons.wikimedia.org/wiki/File:Circadian_rhythm_labeled.jpg#/media/File:Circadian_rhythm_labeled.jpg

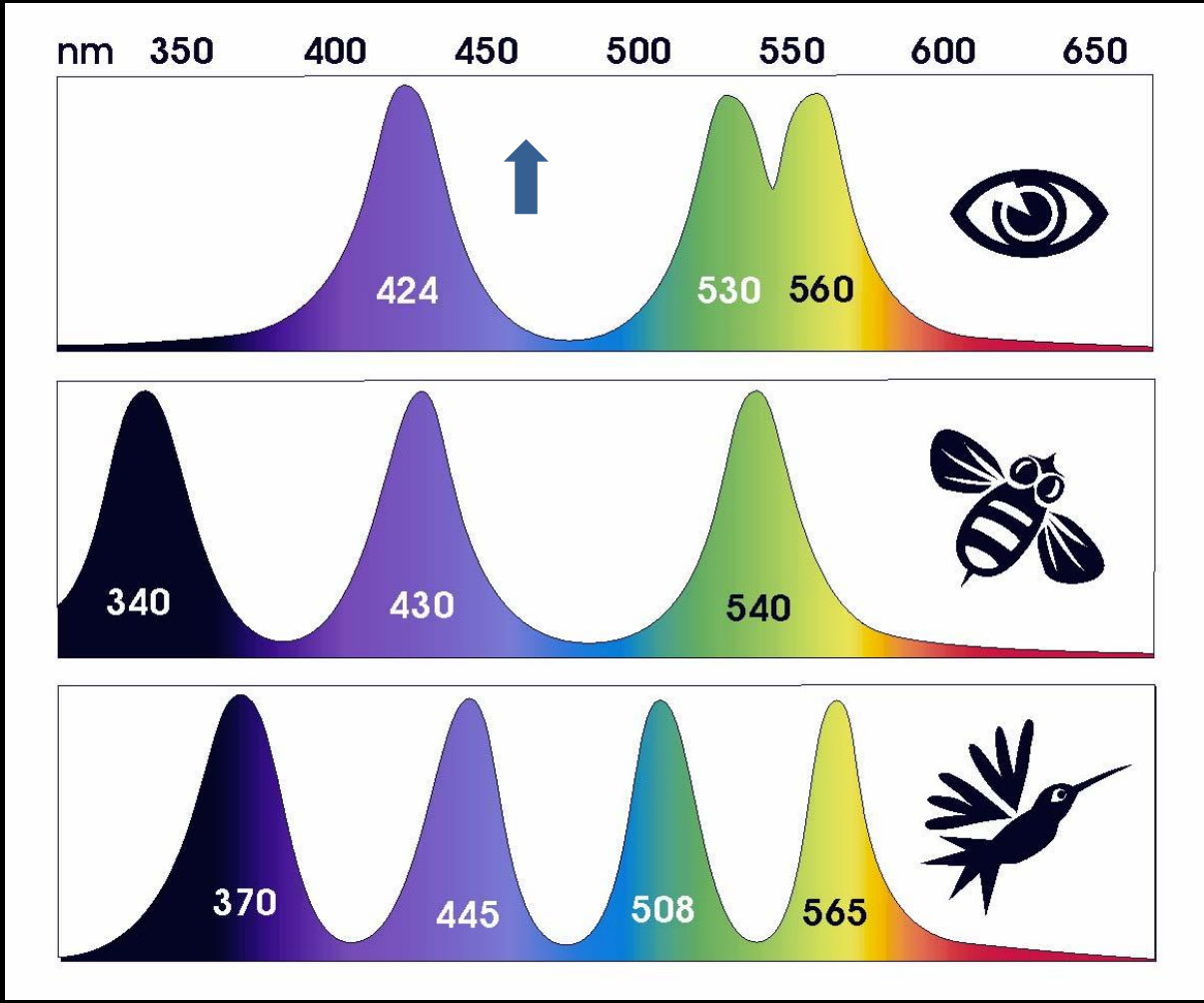
Health risk due to disturbed wake-sleep rhyt

Suppression of melatonin synthesis

- sleep disorder
- cardiovascular disease
- weakening of the immune system
- seasonal depressions
- increased risk of tumour development



Colour perception of humans, bees and colobri



Shery L. Williamson:
https://fieldguidetohummingbirds.files.wordpress.com/2008/11/spectrum.jpg

Sensitivity of the nocturnal eyes

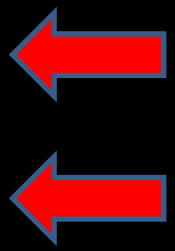
- Nocturnal animals have a highly sensitive visual systems highly adopted to their night niche.
- Some nocturnal insects have superposition compound eyes 100 - 1000 times more sensitive than diurnal insects of the same size
- The thresholds of light intensities influencing most arthropods are at light levels slightly above moonlight (0.5 lux).

Tapetum lucidum

Photo: Annette Krop-Benesch

The night as living space

	Estimated number of described species	Thereof nocturnal[%]
Vertebrates		
Mammals	5 488	63,8
primates (incl. *H. sapiens*)	432	31
bats	1100	100
birds	9 990	19,6
reptiles	8 969	16,6
amphibians	6 433	93,3
Fishes	30 700	14,1
Total	**61 580**	**28,0**
Invertebrates		
Insects	950 000	49,4
Lepidoptera	180 000	77,8
Colleoptera	500 000	60
Crustacean	40 000	50
Arachnidae	98 000	5
Molluscs	81 000	?
Coral	2 175	?
others	61 209	?
Total	**1 232 384**	**64,4**



(Hölker et al. 2010, TREE)

„There is more mechanistic evidence for caterpillar-booms than for baby booms following power outage“

Koert van Geffen

- Moth reproduction activity declines with ALAN, quantity and quality of female pheromone blend decreases (Van Geffen et al., 2015, Insect Conservation and Diversity)
- Frogs (*Rana clamitans melanota*) produce fewer advertisement calls and move more frequently under street lighting than under ambient light conditions (Baker and Richardson, 2006, Canadian Journal of Zoology)
- Fireflies rapidly decrease with increasing light pollution, at light intensities above moonlight levels (0.5 lux) (Hagen et al., 2015, Advances in Entomology)
- Altered Darwinism for song birds, male song birds sing earlier under ALAN, the lamp type might become crucial for reproduction success (Nordt and Klenke, 2013, Environmental Research)

ALAN attraction

ALAN lures insects out of their ecosystem function, enforcing community shifts and loss in biodiversity

In water organisms like amphipods are as well attracted to ALAN in high numbers
(Navaro-Barranco C & Hughes LE. Marine (2015) Pollution Bulletin)

A few winners

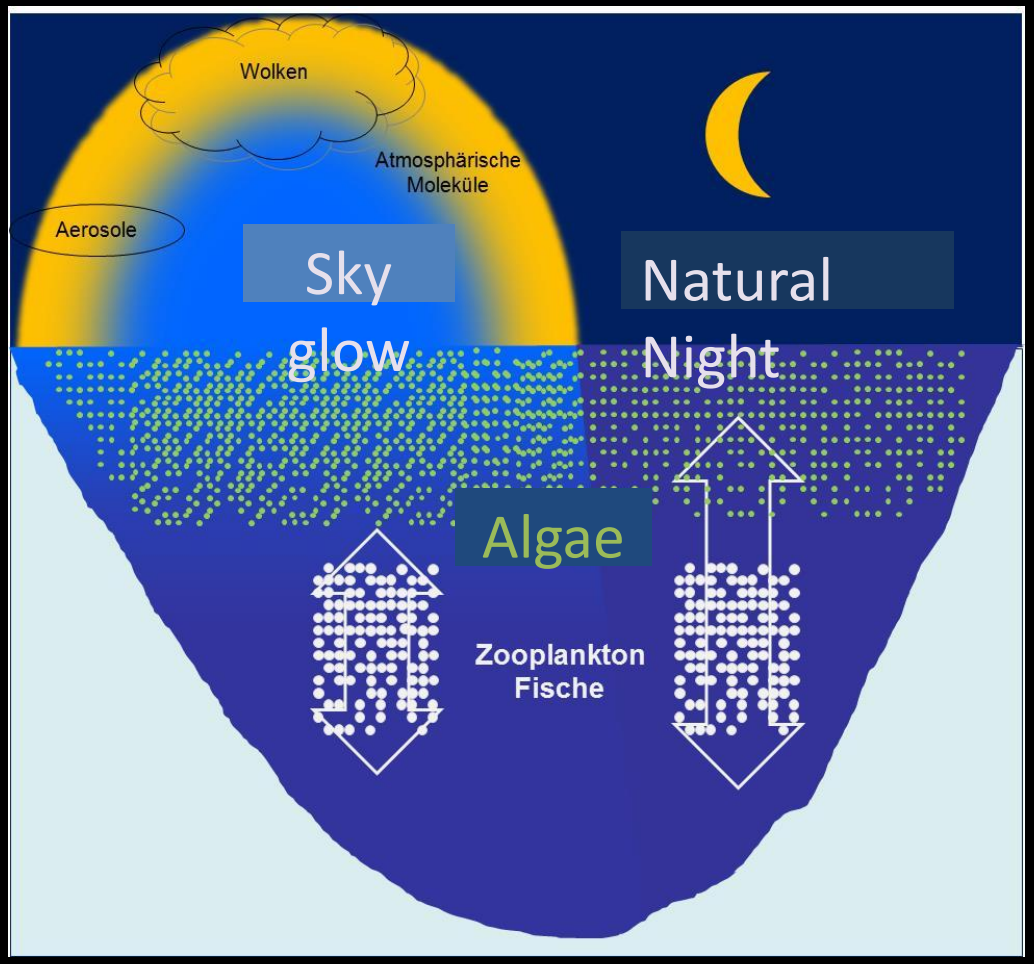
Bridge spider (*Larinioides sclopetarius*)
Increased reproduction rate 300 times in HH harbour city (Kleinteich & Schneider, 2011, Ecological Entomology)

more loosers

Most orb spider species are sensitive to light,
some even require absolute darkness for web building, e.g. the **Walnut orb-weaver** spider (*Nuctenea umbratica*) or the **silver-sided sector spider** (*Zygiella x-notata)* (Zschokke and Herberstein, 2005, Journal of Arachnology)

Migrating species are obstructed by artificial lights at night

Zooplankton stays in the dark



Research at IGB
(Leibniz Institute of Freshwater Ecology)

- ILES = Illuminating lake eco-systems

Research at IGB
(Leibniz Institute of Freshwater Ecology)

- Illuminating an aquatic – terrestrial ecosystem

Photo: Heller

Artificial light at night interferes with ecosystems

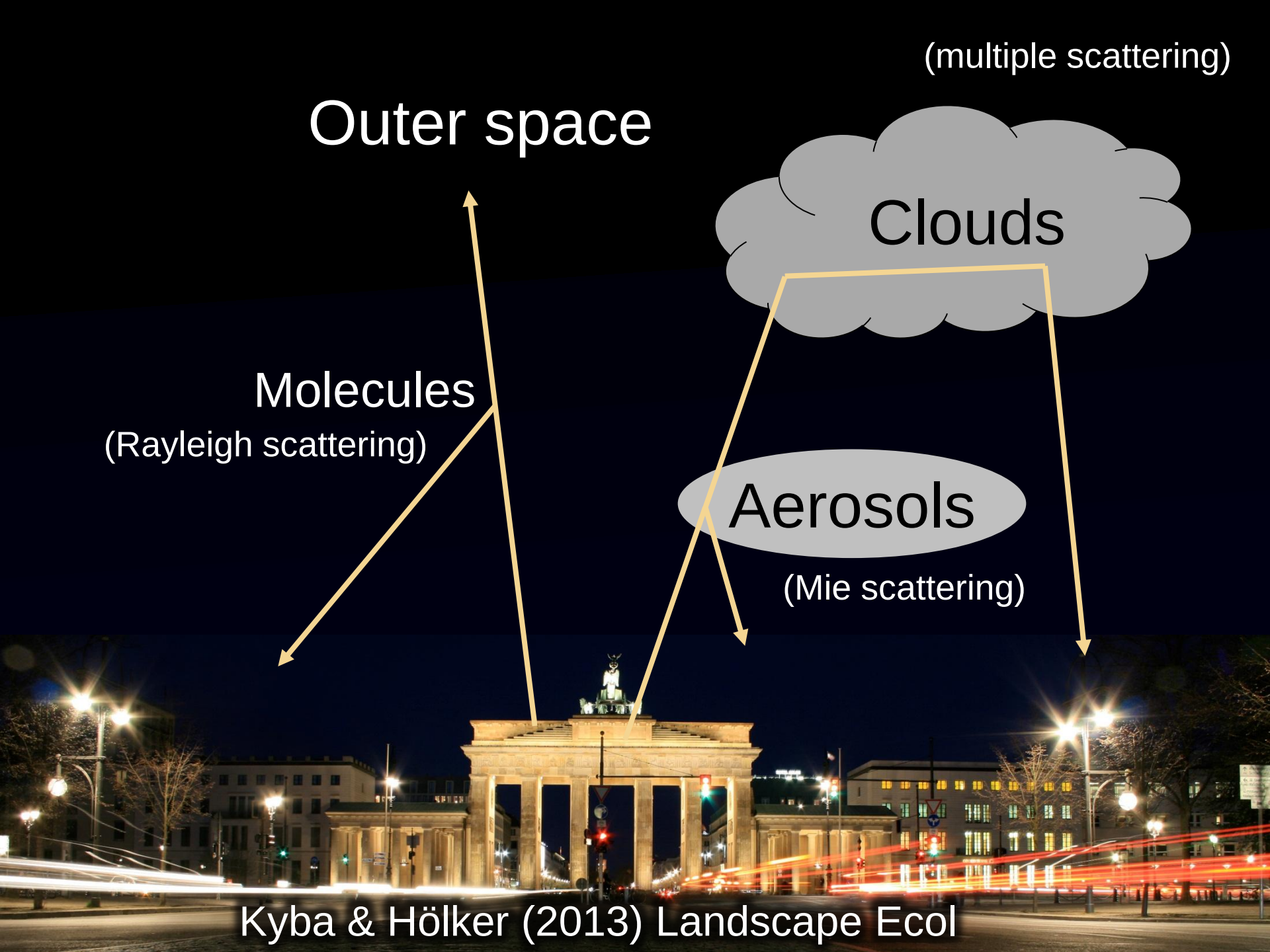
- Change of seasonal and circadian behaviour (nocturnal and diurnal organisms)
- Species which can easily adapt to the changing nightscape increase. Others are threatened in their existence or disappear regionally. The consequences are **changes in spatial species distribution** and **distortions in food webs**
- Nocturnal habitat gets fragmented with consequences for vegetation
- Nighttime ecosystem services (pollination, water clarification) decrease

How can we minimize skyglow?
What is sustainable design?

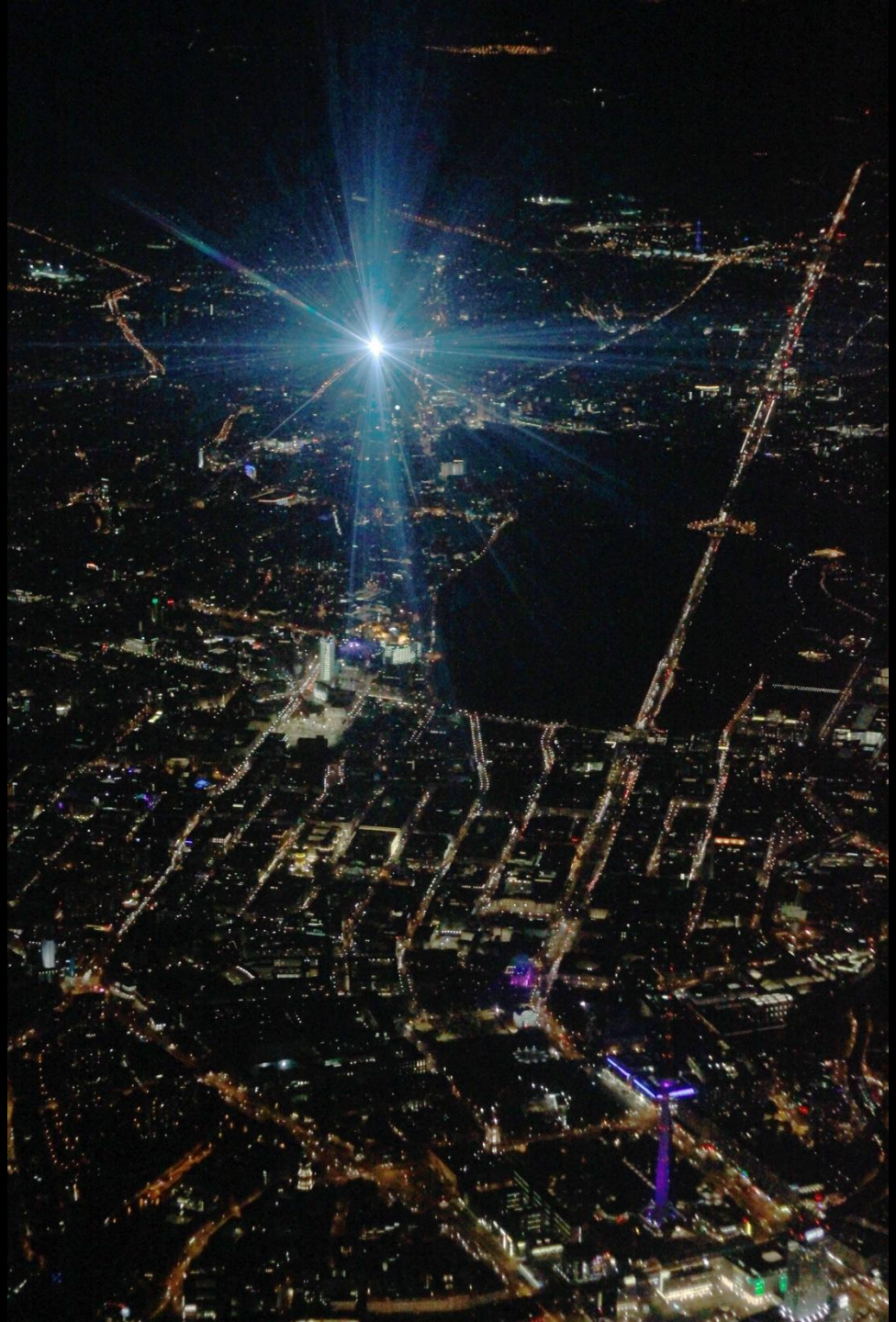
Light exactly WHERE it is needed
Only WHEN it is needed
In exactly the AMOUNT that is needed

Consider the spectrum
is “white” really necessary?

WHERE?



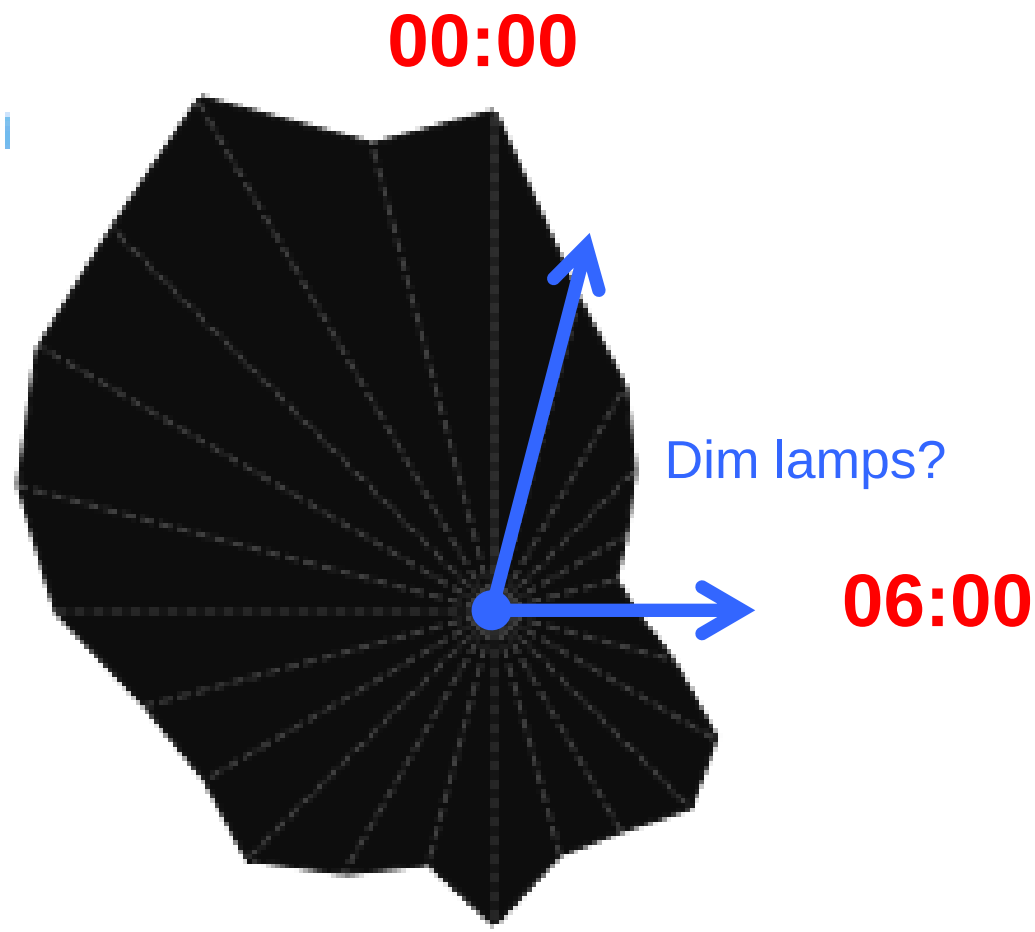
Kyba & Hölker (2013) Landscape Ecol



Lights on the river

WHEN?

Time of crimes in street areas in Chicago



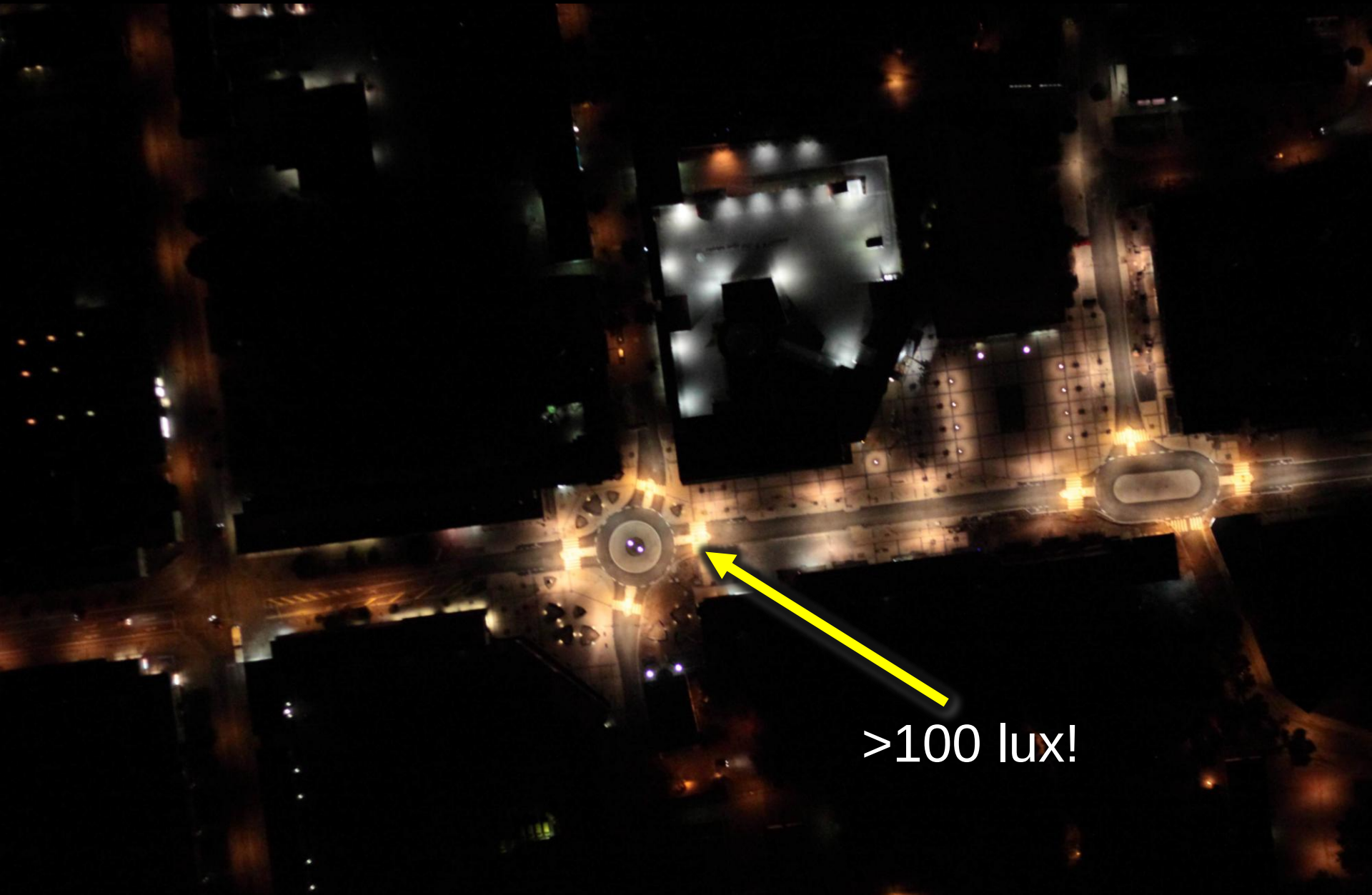
Crime patterns in Chicago:
http://fosslien.com/crime

HOW MUCH?

Checkerboard illusion

See: http://tinyurl.com/ys6nl

“Efficient” Lamps



Parking lot illumination

See article for image

3:1 uniformity

10:1 uniformity

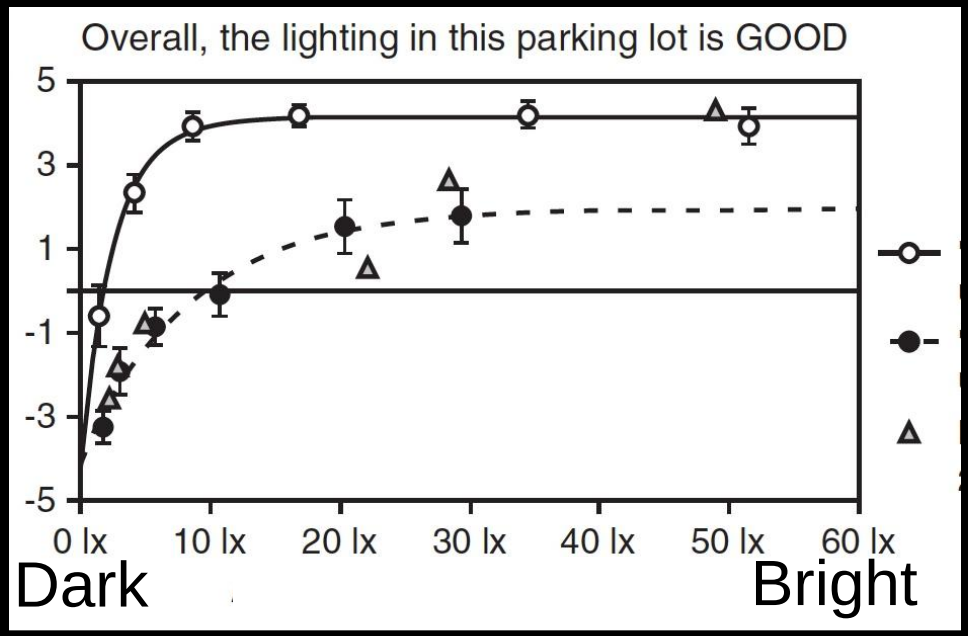
Narendran et al. (2015) Lighting Res. Technol.

Parking lot illumination

Parking lot illumination

Good

Poor



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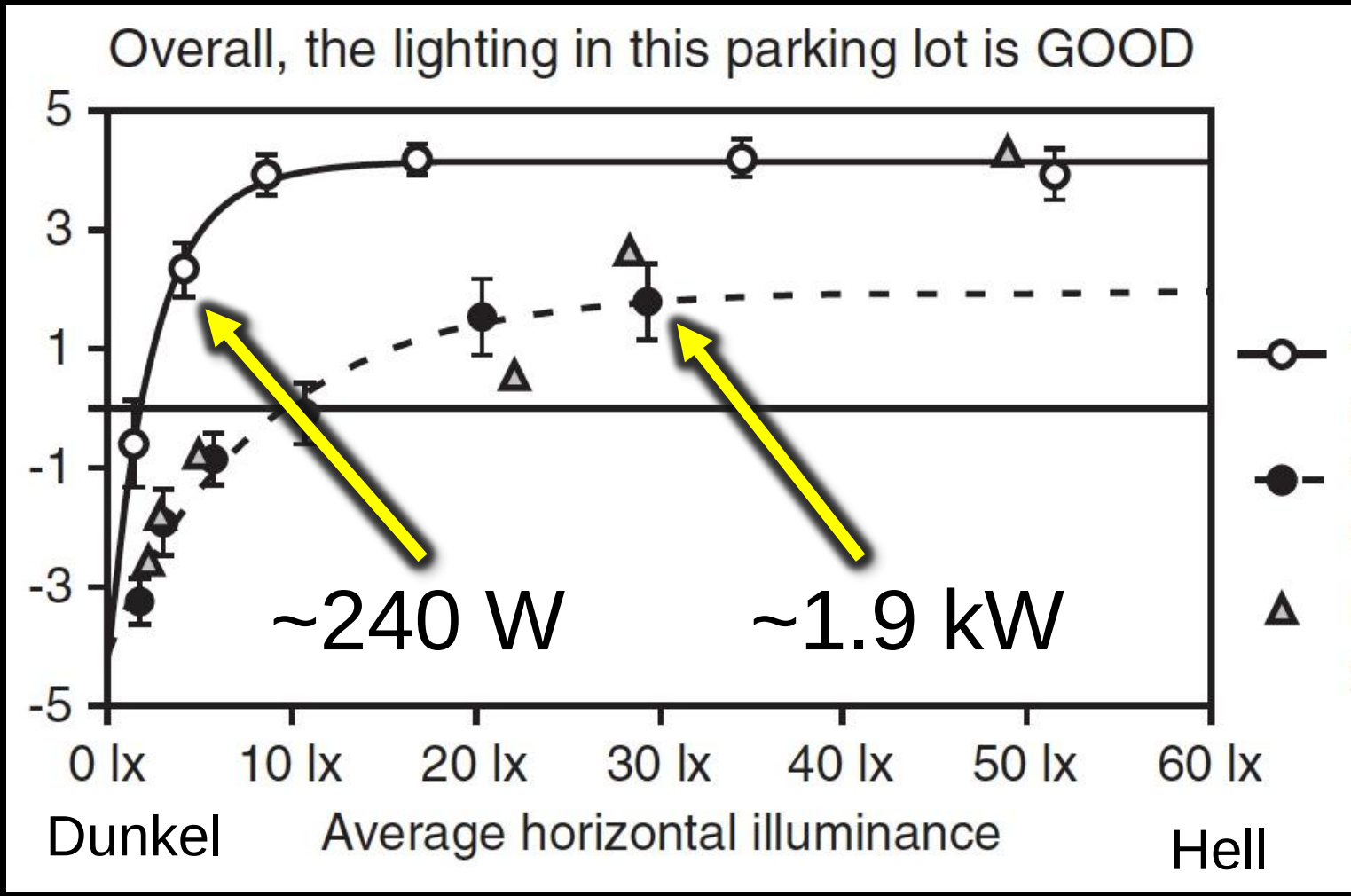
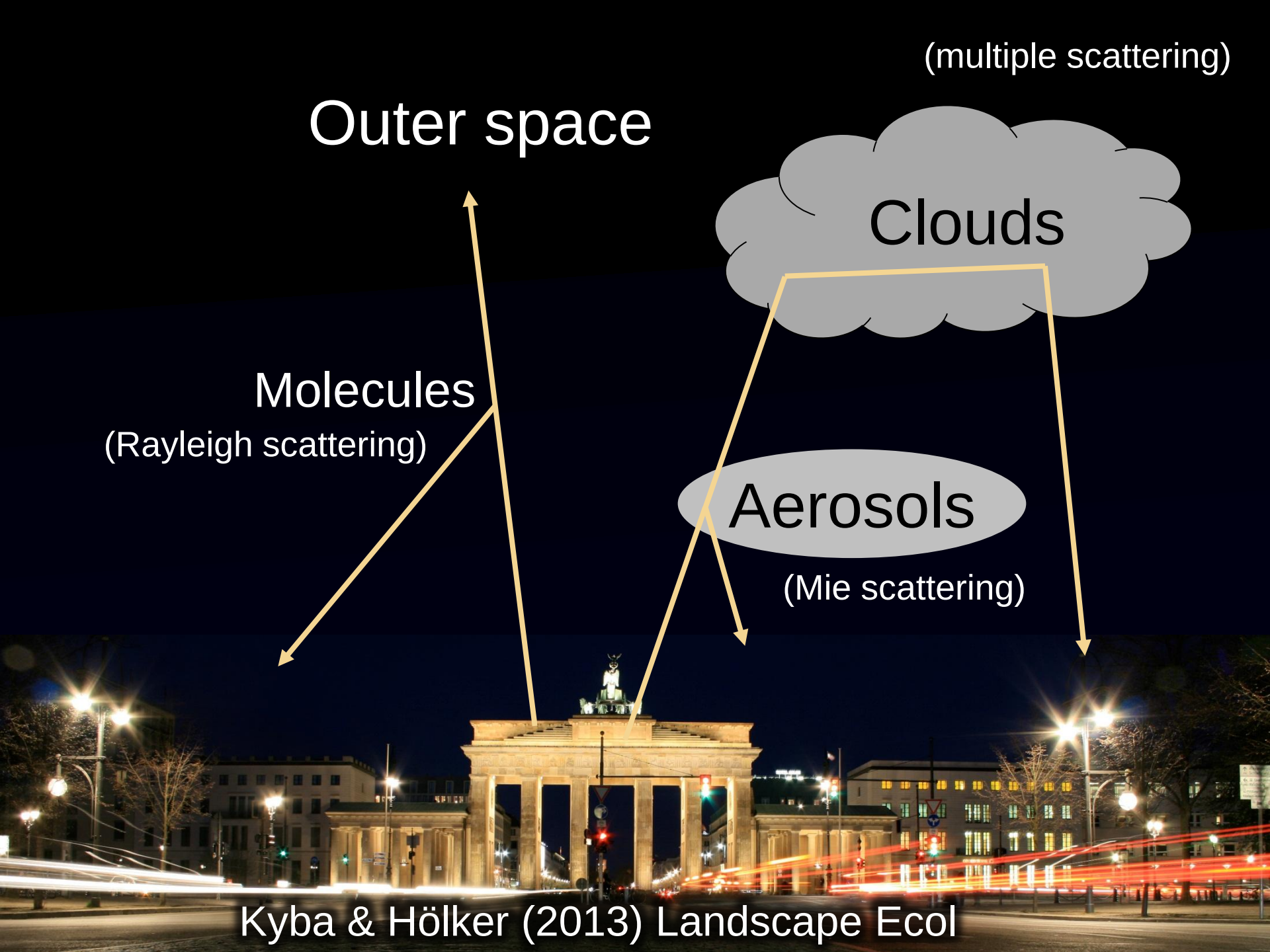


WHAT COLOR?



Kyba & Hölker (2013) Landscape Ecol

Is the light REALLY necessary?

How can we minimize skyglow?
What is sustainable design?

Light exactly WHERE it is needed
Only WHEN it is needed
In exactly the AMOUNT that is needed

Consider the spectrum
is “white” really necessary?

Berlin Festivals

Berlin Music week, 2009, Photo: Philipp Kaden

2015: Ten years festival of lights

Festival of Lights, 2011, Photo: dpa

In 1882 Berlin installed the first electric street lighting

First electric street lighting in Berlin, 1884, Carl Salzmann

In 1930 15.000 electric street lights are installed in Berlin

Weimarer Republik, Stresemann Str. Berlin, 1932

West-Berlin invested in gas lighting,
East-Berlin invested in electrical lighting, predominantly sodium vapour

Gas-lighting, West-Berlin

Rostocker Streetlamp, East-Berlin

Berlin Mitte in the 90s

Photo: Andreas Muh, Pfarrstraße 1992

Raumer Str. 1992, Photo: Michael Lang

Hackesche Höfe 1992, Photo: Michael Lang

Oranienburger Street comming from Hackescher Markt, 1996
Photo: Michael Lang

Reichstag 1997, Photo: Michael Lang

Berlin alleyways

Albert Speer Lamps from the 1930s (TU-Berlin)

Richard Paulick Lamps from 1950s (Hellux.de)

Photo: NASA

Berliner lighting concept (2011)

Demands on safety, energy efficiency, ecology, health and ambient lighting

- In Berlin's public streets and squares there are a total of approximately 224,000 lights with more than 200 types of lamps in more than 1,000 different versions = uneconomical diversity
- The aesthetics of the city and cityscape formative lights should be maintained and equipped with modern, energy efficient technology
- Exclusively warm white light (2700 to 3200 K) should be installed
- Carefully-balanced implementation of DIN EN 13201
- In residential areas, the lighting is reduced to the indispensable minimum necessary and public object illumination be aligned with the smallest possible impact on inhabitants
- Green areas should be largely exempt from lighting

Green areas and lighting

- Recommendation: Avoid direct lighting!
- In Berlin more than 50 different species of mammals and 180 species of birds have been observed
- Illumination, glass facades and the building development on open spaces is reducing their habitat

Thank you!