



STAKEHOLDER MEETING 2018

July 9 - 11 • Boston, MA

Outdoor Lighting Quality - Filtering Fact from Fiction

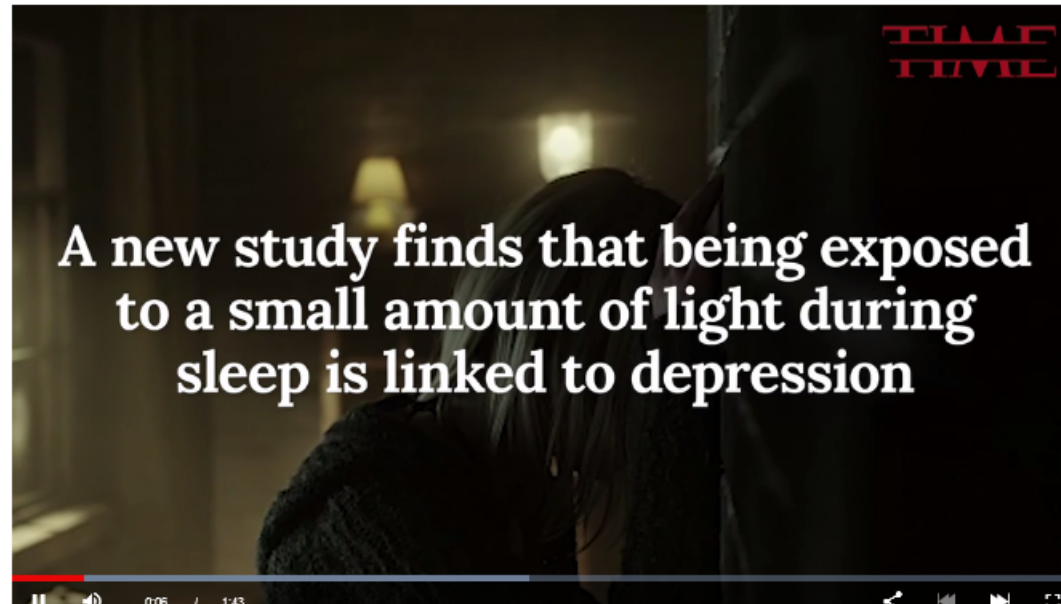
DLC Considerations

- DLC V5.0: Emphasis on quality of Light
 - More reported information about product characteristics
 - Improving the light quality of listed products
 - Enabling easier product differentiation
- Development considerations:
 - How does outdoor lighting affect animals, plants and people?
 - How can information on the QPL be used to minimize negative impacts?

New LED streetlights may double cancer risk, r



Being Exposed to Even a Small Amount of Light During Sleep is Linked to Depression



By **JAMIE DUCHARME** March 7, 2018

TIME Health For more, visit **TIME Health**.



You May Like

Cardiologist: "I Beg Everyone To Quit 3 Foods"

by SmartConsumerToday | Sponsored

These Wallet-Friendly, Walkable Heels Keep Flying Out of Stock

by InStyle | Sponsored

about LED



More from CNN



Dozens of local authorities are following the example of European cities such as London and Berlin, which have replaced old streetlights with LED lights CREDIT: GIANNI CIPRIANO

Photos: Los Angeles LED streetlights

Panelists



Liesel Whitney-Schulte
DLC



Jane Slade
Consultant



Naomi Miller
PNNL



Ute Besenecker
DLC



STAKEHOLDER MEETING 2018

July 9 - 11 • Boston, MA

Starving for Darkness Jane Slade

Light Pollution

“Light pollution is an unwanted consequence of outdoor lighting and includes such effects as sky glow, light trespass, and glare.”¹



1. “Light Pollution.” Lighting Research Center. Rensselaer Polytechnic Institute, February 2007. Web. 9 February 2016.

Skyglow

“Brightening of the sky caused by outdoor lighting and natural atmospheric and celestial factors.”²



2. “Light Pollution.” Lighting Research Center. Rensselaer Polytechnic Institute, February 2007. Web. 9 February 2016.

Glare

"Excessive brightness that causes visual discomfort and decreases visibility."³



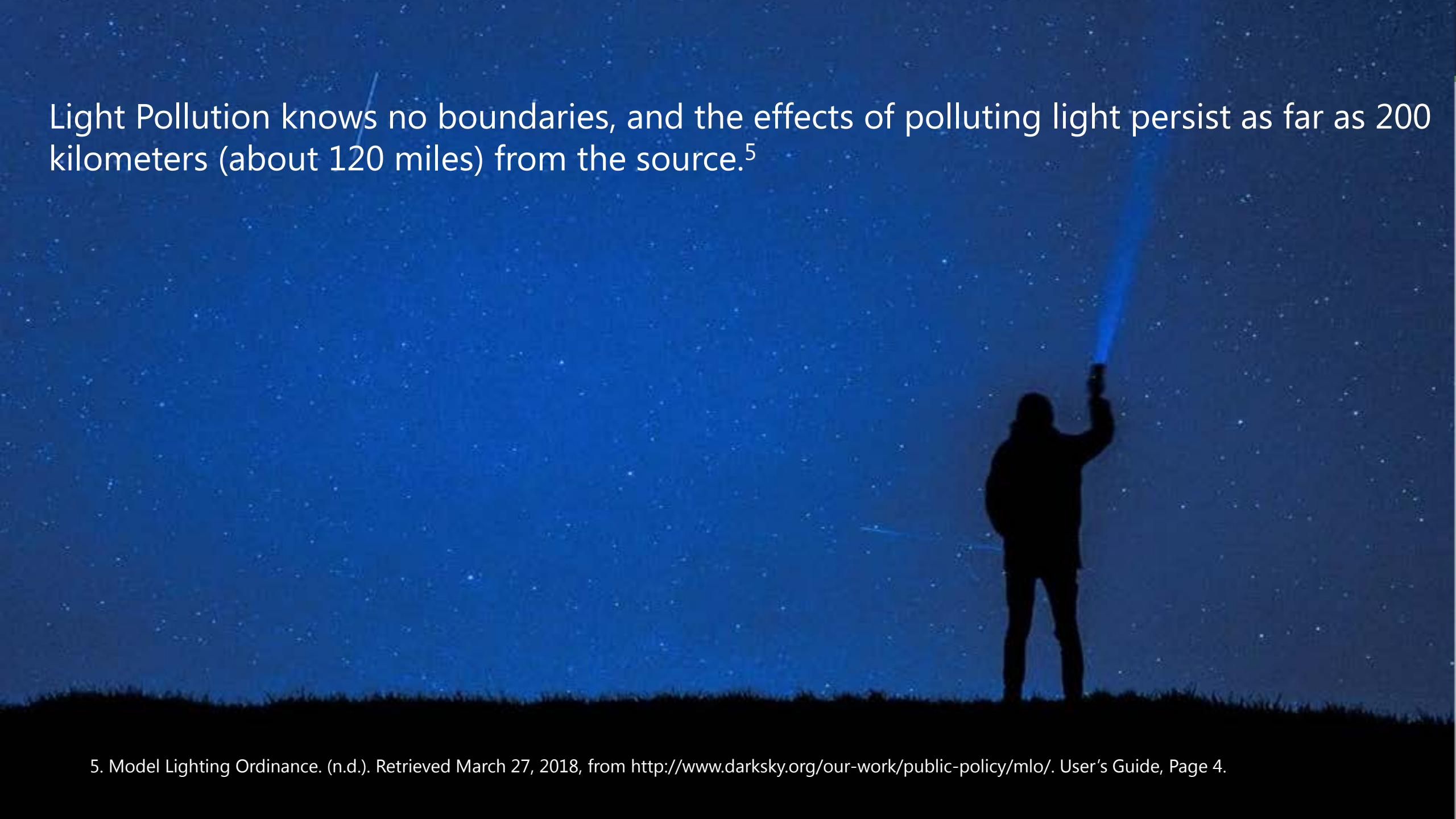
The Mechanics of Light Pollution

The air, seemingly invisible, is filled with soft particulate.

These particles serve as trillions of tiny little mirrors, re-reflecting light from the original light sources.

This re-reflection creates clouds of light that obstruct darkness, the natural rhythm of light, and the night's sky.

Light Pollution knows no boundaries, and the effects of polluting light persist as far as 200 kilometers (about 120 miles) from the source.⁵



5. Model Lighting Ordinance. (n.d.). Retrieved March 27, 2018, from <http://www.darksky.org/our-work/public-policy/mlo/>. User's Guide, Page 4.



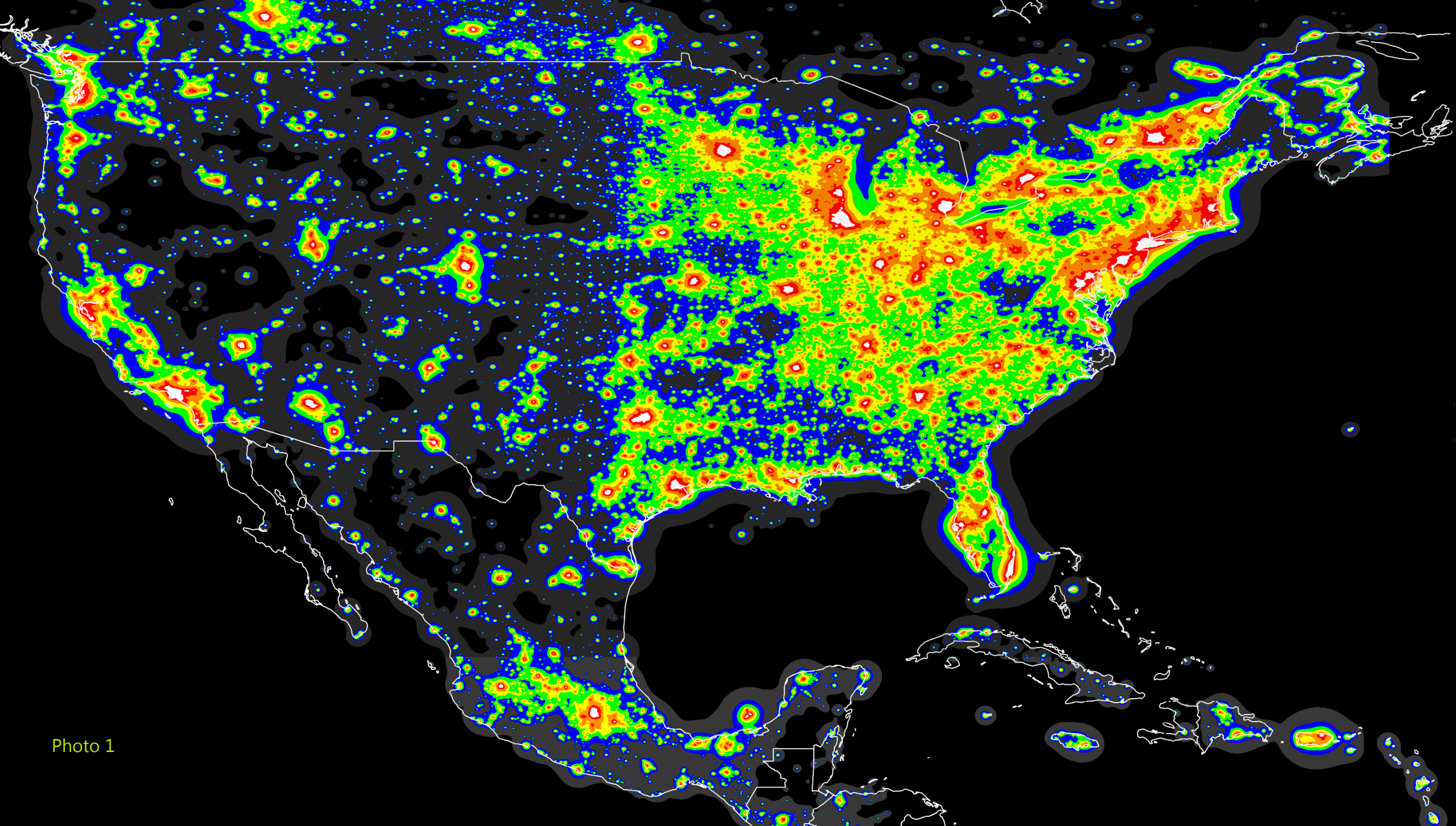


Photo 1

The sky was our first screen...

...revealing constantly changing data about the time, season, location, direction, and the earth's atmospheric conditions.



How does exterior lighting affect wildlife?

Sea Turtles





“All animals, not just humans, depend on a regular interval of daylight and darkness for proper functioning of behavioral, reproductive, and immune systems.”⁷

Direct Effects of Light Pollution on Wildlife

Disorients and distracts animals

Triggers reproductive behaviors at the wrong periods

Frustrates behaviors around feeding and pollination

Alters migration





Insects

According to Naturalist E. O. Wilson of Harvard University:

If all mankind were to disappear, the world would regenerate back to the rich state of equilibrium that existed ten thousand years ago.

If insects were to vanish, the environment would collapse into chaos.

Dung Beetles

- Utilize astro-navigation to travel in straight, efficient paths¹⁶
- A study placed dung beetles in a planetarium¹⁷



16. 3 Insects Affected by Light Pollution. (2017, February 14). Retrieved March 25, 2018, from <http://www.darksky.org/3-insects-affected-by-light-pollution/>

17. Ibid

Dung Beetles

- When the planetarium lights were on, the beetles moved in straight lines¹⁸
- When the lights were turned off, their paths became scattered and random¹⁹



18. 3 Insects Affected by Light Pollution. (2017, February 14). Retrieved March 25, 2018, from <http://www.darksky.org/3-insects-affected-by-light-pollution/>

19. Ibid

Fireflies

A Language of Light

Photo 3



Fireflies and Human Impact

- There are over 2000 species of fireflies⁹
- Fireflies inhabit every continent except Antarctica
- One study showed a 50% decrease in Firefly flashes in the presence of light¹⁰
- The broader spectrum of LED lights compared to High Pressure Sodium may increase disruption in communication

9. Fireflies Need the Dark to Talk with Light. (2017, July 26). Retrieved March 25, 2018, from <http://www.darksky.org/fireflies-need-the-dark-to-talk-with-light/>

10. Costin, K. J., & Boulton, A. M. (2016). A Field Experiment on the Effect of Introduced Light Pollution on Fireflies (Coleoptera: Lampyridae) in the Piedmont Region of Maryland. *The Coleopterists Bulletin*, 70(1), 84-86. doi:10.1649/072.070.0110



Pollination and Insects



Bees



If the bee disappeared off the surface of the globe, then man would have only four years of life left. No more bees, no more pollination, no more plants, no more animals, no more man.

-Albert Einstein

Impacts of Exterior Lighting on Pollination

In one study¹⁵, lit meadows as compared to unlit meadows:

- Received 62% less visits by nocturnal insects
- Had 29% fewer pollinating insects
- Bore 13% less fruits in the plant studied, cabbage thistle

15. Knop, E., Zoller, L., Ryser, R., Gerpe, C., Hörler, M., & Fontaine, C. (2017). Artificial light at night as a new threat to pollination. *Nature*. doi:10.1038/nature23288



Bats

- 900 Different Species
- 100% are nocturnal
- They are the only flying mammal
- Help to control insect populations





Bats

"The habit of feeding at artificial lights is now so common and widespread among bats that it must be considered part of the normal life habit of many species."²³

23. Rich, C., & Longcore, T. (2013). Ecological Consequences of Artificial Night Lighting. Washington: Island Press. Page 43.

Bats



Birds

A large flock of birds, likely geese, is captured in flight against a backdrop of soft, white clouds. The birds are arranged in a classic V-formation, with several smaller groups and individual birds scattered throughout the frame. The sky is a pale, hazy blue, and the overall mood is serene yet somber, reflecting the text's message about bird mortality.

It is estimated that nearly one billion birds die from flying into buildings and windows in the North America every year.²⁸

28. St. Fleur, N. (2016, April 7). Illuminating the Effects of Light Pollution. The New York Times.



Photo 4

Lighting Design for Birds

- 
- Turn off lights during peak migration periods, cloud coverage, and inclement weather
 - Take special precaution when designing for buildings 300 feet or below in height,⁴⁰ from façade treatments to other innovations
 - Use green and blue wavelengths when possible,⁴¹ avoiding white and red wavelengths that interfere with bird migration⁴²

40. Standards for Bird-Safe Buildings. (2011, June). San Francisco Planning Department. Retrieved March 26, 2018, from <http://sf-planning.org/standards-bird-safe-buildings>. Page 25.

41. Ibid. Page 17.

42. Zielinska-Dabkowska, K. M. (2014, November 5). Journey towards light – evolutionary adaptations of humans, flora and fauna. Guidelines for safe and healthy illumination. Retrieved March 26, 2018, from www.researchgate.net/publication/285056341. Page 274.

Oceanic Creatures

- Whales migrate over many thousands of miles of open ocean



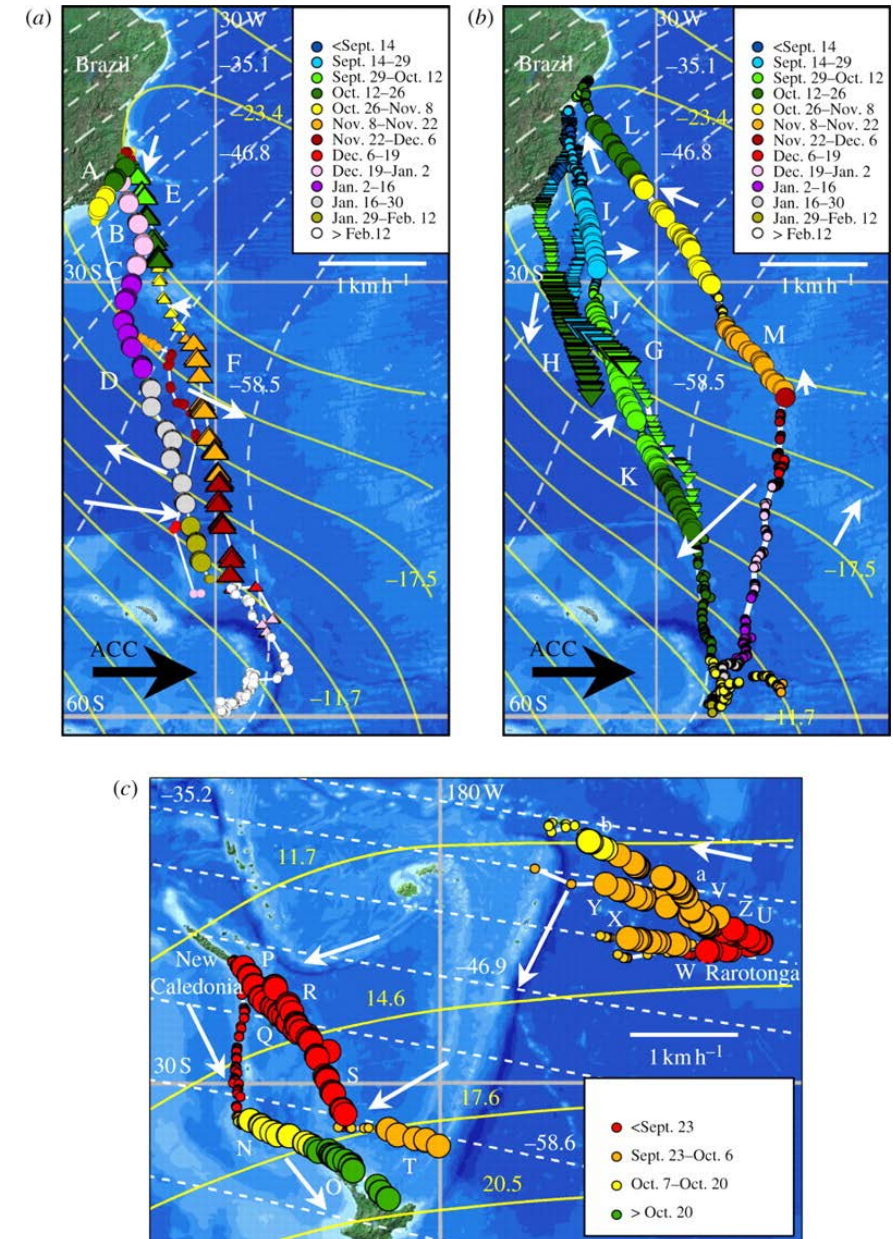
- The waters have strong currents and unpredictable turbulence

Humpback Whale Migration

Never deviated:

- More than 5 degrees off course
- Often not more than 1 degree²⁶

26. Horton, T. W., Holdaway, R. N., Zerbini, A. N., Hauser, N., Garrigue, C., Andriolo, A., & Clapham, P. J. (2011). Straight as an arrow: Humpback whales swim constant course tracks during long-distance migration. *Biology Letters*, 7(5), 674-679. doi:10.1098/rsbl.2011.0279



Humpback Whale Migration

The study's conclusion hypothesizes that whales also utilize the moon and stars to orient themselves on their long paths ²⁷



27. Horton, T. W., Holdaway, R. N., Zerbini, A. N., Hauser, N., Garrigue, C., Andriolo, A., & Clapham, P. J. (2011). Straight as an arrow: Humpback whales swim constant course tracks during long-distance migration. *Biology Letters*, 7(5), 674-679. doi:10.1098/rsbl.2011.0279

The things we do not see: microorganisms



Zooplankton

- Tiny animals inhabiting water, sometimes microscopic in size
- Exquisitely sensitive to light
- Vertically migrate depending on small shifts in light magnitude
- They avoid the surface of the water during the day due to predators and UV light³⁰

Zooplankton

- Artificial light can alter the migration of Zooplankton, both in time and distance³¹
- Inhibiting the migration of Zooplankton can drastically alter the water's ecosystem, such as potentially causing algae blooms

Trees

Artificial light can have the following impact:

- The photoperiod, or duration of light, impacts:
 - Leaf development, shape, and pigment³²
 - Leaf fall and timing in Autumn³³
 - Root growth³⁴
- Constant light prevents dormancy during the harsh winter³⁵
- Flowering patterns can also be altered³⁶

32. Chaney, W. R. (2002). Does Night Lighting Harm Trees? Forestry and Natural Resources, Purdue University, 3. Retrieved March 26, 2018, from <https://www.extension.purdue.edu/extmedia/fnr/fnr-faq-17.pdf>. Page 3.

33. Ibid

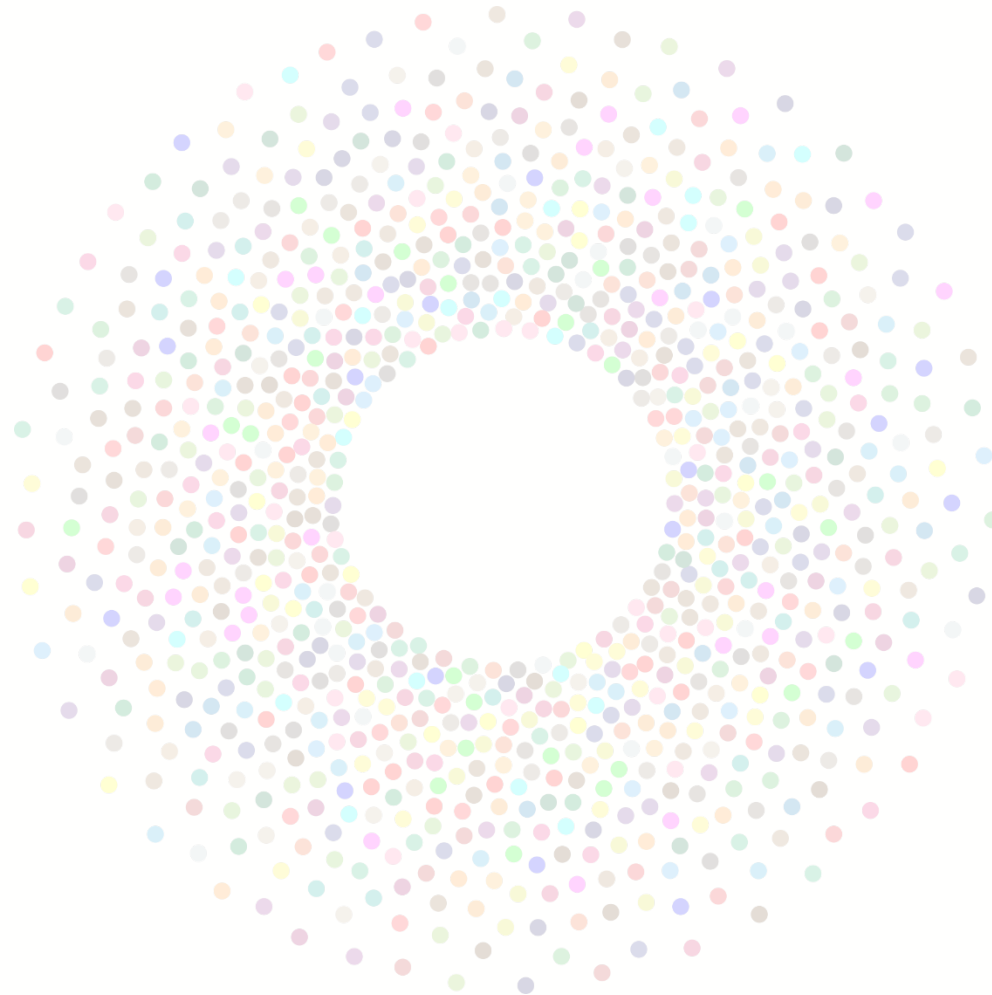
34. Ibid

35. Zielinska-Dabkowska, K. M. (2014, November 5). Journey towards light – evolutionary adaptations of humans, flora and fauna. Guidelines for safe and healthy illumination. Retrieved March 26, 2018, from www.researchgate.net/publication/285056341. Page 272.

36. Ibid



Biodiversity & Interdependence



The Best Prescriptions For Exterior Lighting

- Design for specific applications
- Conduct photometric studies
- Provide the right amount of light: not more, not less
- Use Dark-Sky compliant fixtures/ Shielding
- Utilize warmer CCTs, or SPDs with higher wavelengths
- Utilize controls to limit impact
- Avoid uplighting always









Bibliography

1. "Light Pollution." Lighting Research Center. Rensselaer Polytechnic Institute, February 2007. Web. 9 February 2016.
2. Ibid
3. Fighting Light Pollution: Smart Lighting Solutions for Individuals and Communities. Mechanicsburg, PA: Stackpole Books; 2012. Page 4.
4. Ibid
5. Model Lighting Ordinance. (n.d.). Retrieved March 27, 2018, from <http://www.darksky.org/our-work/public-policy/mlo/>. User's Guide, Page 4.
6. Solastalgia. (2017, September 12). In *Wikipedia, The Free Encyclopedia*. Retrieved 00:48, February 12, 2018, from <https://en.wikipedia.org/w/index.php?title=Solastalgia&oldid=800200969>
7. Fighting Light Pollution: Smart Lighting Solutions for Individuals and Communities. Mechanicsburg, PA: Stackpole Books; 2012. Page 25.
8. Ibid. Page 26.
9. Fireflies Need the Dark to Talk with Light. (2017, July 26). Retrieved March 25, 2018, from <http://www.darksky.org/fireflies-need-the-dark-to-talk-with-light/>
10. Costin, K. J., & Boulton, A. M. (2016). A Field Experiment on the Effect of Introduced Light Pollution on Fireflies (Coleoptera: Lampyridae) in the Piedmont Region of Maryland. *The Coleopterists Bulletin*, 70(1), 84-86. doi:10.1649/072.070.0110
11. 3 Insects Affected by Light Pollution. (2017, February 14). Retrieved March 25, 2018, from <http://www.darksky.org/3-insects-affected-by-light-pollution/>
12. Dell'Amore, C. (2014, January 29). Migrating Monarch Butterflies in "Grave Danger," Hit New Low. Retrieved March 26, 2018, from <https://news.nationalgeographic.com/news/2014/01/140129-monarch-butterflies-mexico-animals-science-environment-migration-nation/>
13. Bruce-White, C., & Shardlow, M. (2011). A review of the impact of artificial light on invertebrates. Totton: Buglife - The Invertebrate Conservation Trust. Page 14.
14. Dell'Amore, C. (2014, January 29).
15. Knop, E., Zoller, L., Ryser, R., Gerpe, C., Hörl, M., & Fontaine, C. (2017). Artificial light at night as a new threat to pollination. *Nature*. doi:10.1038/nature23288
16. 3 Insects Affected by Light Pollution. (2017, February 14). Retrieved March 25, 2018, from <http://www.darksky.org/3-insects-affected-by-light-pollution/>
17. Ibid
18. Ibid
19. Ibid
20. Rich, C., & Longcore, T. (2013). *Ecological Consequences of Artificial Night Lighting*. Washington: Island Press. Page 28.
21. Ibid
22. Ibid. Page 32.
23. Ibid. Page 43.
24. Horton, T. W., Holdaway, R. N., Zerbini, A. N., Hauser, N., Garrigue, C., Andriolo, A., & Clapham, P. J. (2011). Straight as an arrow: Humpback whales swim constant course tracks during long-distance migration. *Biology Letters*, 7(5), 674-679. doi:10.1098/rsbl.2011.0279
25. Ibid
26. Ibid
27. Ibid
28. St. Fleur, N. (2016, April 7). Illuminating the Effects of Light Pollution. *The New York Times*.
29. Dominoni, D., Quetting, M., & Partecke, J. (2013). Artificial light at night advances avian reproductive physiology. *Proceedings of the Royal Society B: Biological Sciences*, 280(1756), 20123017-20123017. doi:10.1098/rspb.2012.3017
30. Rich, C., & Longcore, T. (2013). *Ecological Consequences of Artificial Night Lighting*. Washington: Island Press. Page 372.
31. Ibid
32. Chaney, W. R. (2002). Does Night Lighting Harm Trees? *Forestry and Natural Resources*, Purdue University, 3. Retrieved March 26, 2018, from <https://www.extension.purdue.edu/extmedia/fnr/fnr-faq-17.pdf>. Page 3.
33. Ibid
34. Ibid
35. Zielinska-Dabkowska, K. M. (2014, November 5). Journey towards light – evolutionary adaptations of humans, flora and fauna. Guidelines for safe and healthy illumination. Retrieved March 26, 2018, from www.researchgate.net/publication/285056341. Page 272.
36. Ibid
37. Model Lighting Ordinance. (n.d.). Retrieved March 27, 2018, from <http://www.darksky.org/our-work/public-policy/mlo/>
38. Zielinska-Dabkowska, K. M. (2014, November 5). Journey towards light – evolutionary adaptations of humans, flora and fauna. Guidelines for safe and healthy illumination. Retrieved March 26, 2018, from www.researchgate.net/publication/285056341. Page 274.
39. Ibid
40. Standards for Bird-Safe Buildings. (2011, June). San Francisco Planning Department. Retrieved March 26, 2018, from <http://sf-planning.org/standards-bird-safe-buildings>. Page 25.
41. Ibid. Page 17.
42. Zielinska-Dabkowska, K. M. (2014, November 5). Journey towards light – evolutionary adaptations of humans, flora and fauna. Guidelines for safe and healthy illumination. Retrieved March 26, 2018, from www.researchgate.net/publication/285056341. Page 274.
43. Flagstaff AZ Images at Night Show Success with Years of Dark Sky Advocacy. (2017, January 20). Retrieved February 11, 2018, from <http://www.darksky.org/flagstaff-az-images-at-night-show-success-with-years-of-dark-sky-advocacy/>
44. Ibid
45. Night Sky Data to the People! (2015, December 08). Retrieved February 11, 2018, from <http://www.darksky.org/night-sky-data-to-the-people/>

Photographic Sources

1. File:global_northam_Vb.tif (2000). Light Pollution Science and Technology Institute. Retrieved March 25, 2018 from <http://www.inquinamentoluminoso.it/worldatlas/pages/fig2.htm>.
2. File:Synthesis of Melatonin from Serotonin through two enzymatic steps.png. (2017, February 4). Wikimedia Commons, the free media repository. Retrieved 10:55, February 19, 2018 from https://commons.wikimedia.org/w/index.php?title=File:Synthesis_of_Melatonin_from_Serotonin_through_two_enzymatic_steps.png&oldid=232389703.
3. MacGillivray, M. (2010, June 5). Firefly [After nightfall, the last open field before the wood lot is almost always filled with the green blinking lights of fireflies, otherwise known as lightning bugs.]. Retrieved February 16, 2018, from <https://www.flickr.com/photos/qmnonic/4684229596>. License: <https://creativecommons.org/licenses/by/2.0/>
4. St. Fleur, N. (2016, April 7). Illuminating the Effects of Light Pollution. The New York Times. Photo by Leighton Jones.
5. Skyglow Project by Harun Mehmedinovic and Gavin Heffernan
6. File:High Pressure Sodium Lamps.JPG. (2016, December 14). Wikimedia Commons, the free media repository. Retrieved 19:44, March 26, 2018 from https://commons.wikimedia.org/w/index.php?title=File:High_Pressure_Sodium_Lamps.JPG&oldid=226243205.
7. Skyglow Project by Harun Mehmedinovic and Gavin Heffernan
8. Ibid
9. Ibid
10. Ibid
11. Ibid
12. Ibid
13. Ibid



Thank you!

Questions? Comments?
janeslade@gmail.com



Exterior Lighting Panel

Naomi Miller
Senior Lighting Scientist
Pacific Northwest National Laboratory



Pacific Northwest
NATIONAL LABORATORY

*Proudly Operated by **Battelle** Since 1965*

Outdoor street lighting gets a bad rap

Accused of

- Interfering with sleep
- Creating light pollution and interfering with star viewing
- Screwing up circadian rhythms
- Contributing to obesity, diabetes
- Contributing to human cancers
- Contributing to bird deaths
- Changing natural habitats and critter foraging and mating habits
- Introducing debilitating glare
- And... more

LED Streetlights Are Giving Neighborhoods the Blues

Early adopters of LED street lighting are struggling with glare and light pollution



Photo: Bob O'Connor

Blue Light FAQs:

<https://www.energy.gov/eere/ssl/downloads/street-lighting-and-blue-light-faqs>

Why was exterior lighting installed?

- Safety from tripping, falling
- Safety from being hit by bicycles, cars, skateboards
- Location orientation, especially walking to/from work and school or the grocery store
- Seeing signage
- Personal security from harm, intimidation from people and mean critters
- Pleasing appearance of the neighborhood / campus area and creating a sense of place at night
- (And occasionally.... building load for the utility)



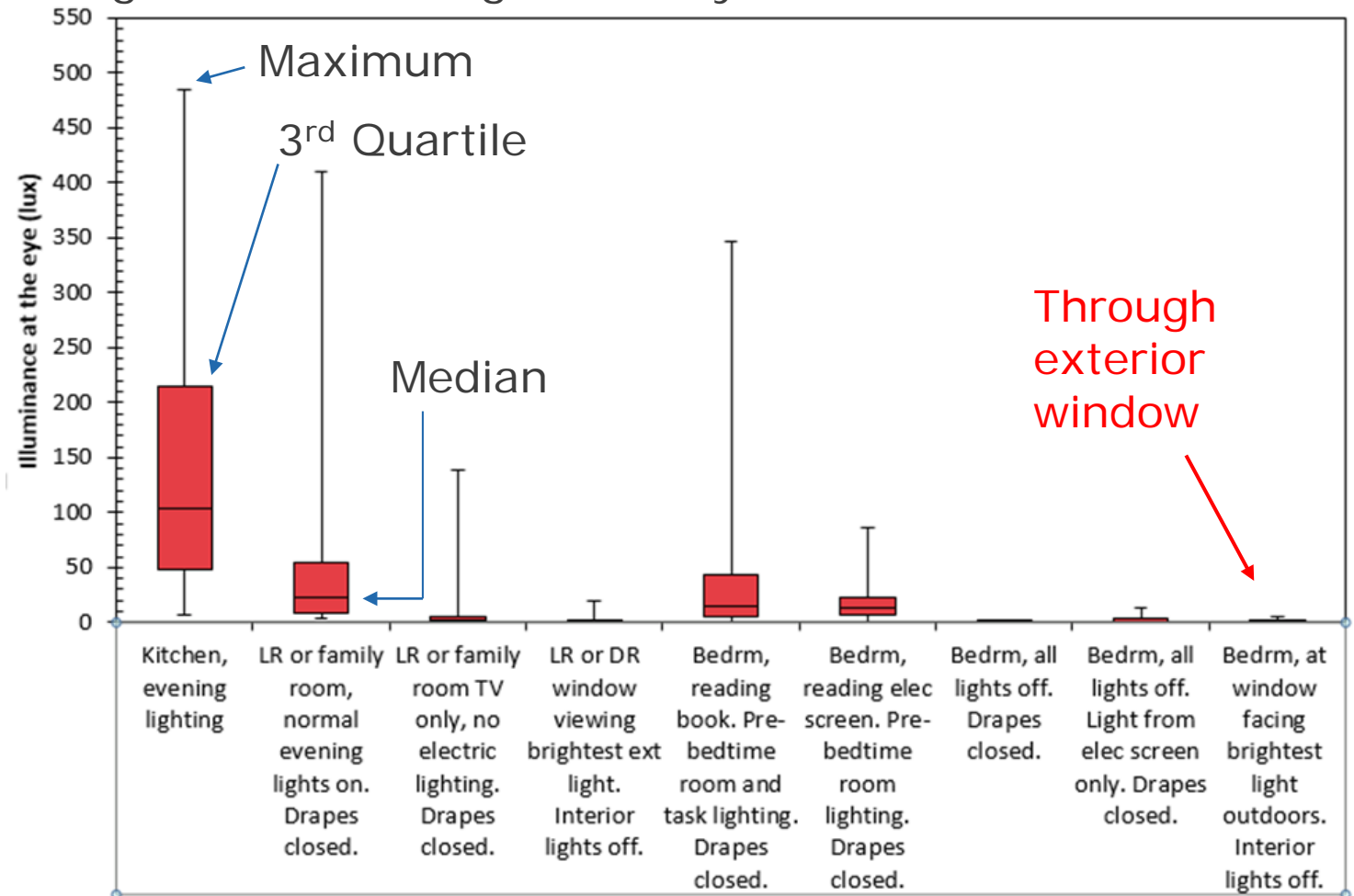
Photo courtesy of
Philips Lumec

How much light exposure do we get at night?

Our informal investigation of interior lighting exposures in the homes of IALD and IES members showed much higher levels present from interior than exterior sources.

<https://www.iald.org/News/In-the-News/Home-Nighttime-Light-Exposures-How-Much-Are-We-Re>

Light Meter readings taken by 30 IALD and IES members



Should we get rid of all lighting?

- Yes. Where there are no serious human needs, or where human health is subordinate to animal and environmental health.
- Carry your own light where possible.
- Where that is infeasible, LEDs are the answer
 - Spectral choices or SPD tuning per time of night
 - Distribution control – LEDs directionally and optically controllable
 - Fully dimmable to low levels of 5% or less, energy savings almost proportional
 - Responsive to occupancy sensing, time of day, travel congestion, police alarms, etc.



© Warner Bros

Image from bustle.com



Skyglow

- Based on the DOE Sky Glow Investigation, the most effective measures we have (if we are to benefit from electric street lighting) are, in order:
 - Eliminating uplight
 - Reducing light output (either upon installation or dimming later)
 - Altering the spectral content (while still retaining a broad spectrum source) ... and CCT is a poor metric for blue light content
- All of which are easier to do with LEDs than any other mainstream light source technology yet invented.

<https://www.energy.gov/eere/ssl/downloads/investigation-led-street-lighting-s-impact-sky-glow>



And what about glare?

- Utilities and municipalities are starting to space LED streetlights more widely to save pole cost. (up to 8:1 spacing/mounting height ratio)
- LEDs can do this. Unfortunately. Unintended consequences include:
 - *Horrible* glare for drivers and pedestrians at angles such as 75 degrees from nadir
- Bare LEDs are painful, whether indoors or out. Diffusion, indirect optics, and waveguides are effective at reducing glare
- The IES, CIE, and other Standards Organizations are working on improved glare metrics, but should also reconsider uniformity recommendations.



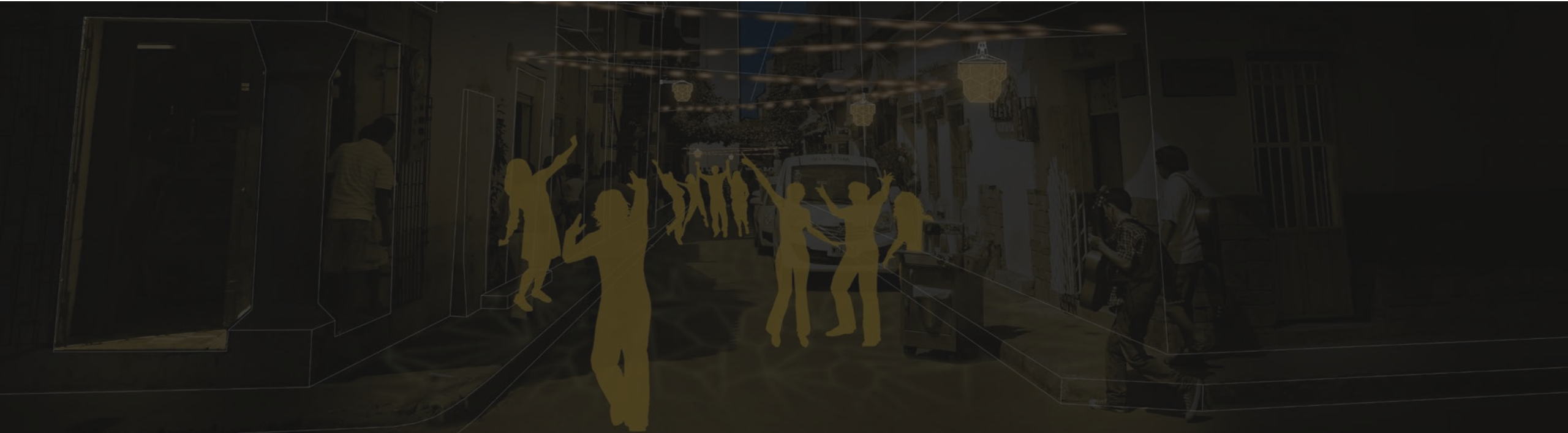


Ute Besenecker - DLC

A Prototype Pilot

Smart Everyday Nighttime Design in Cartagena

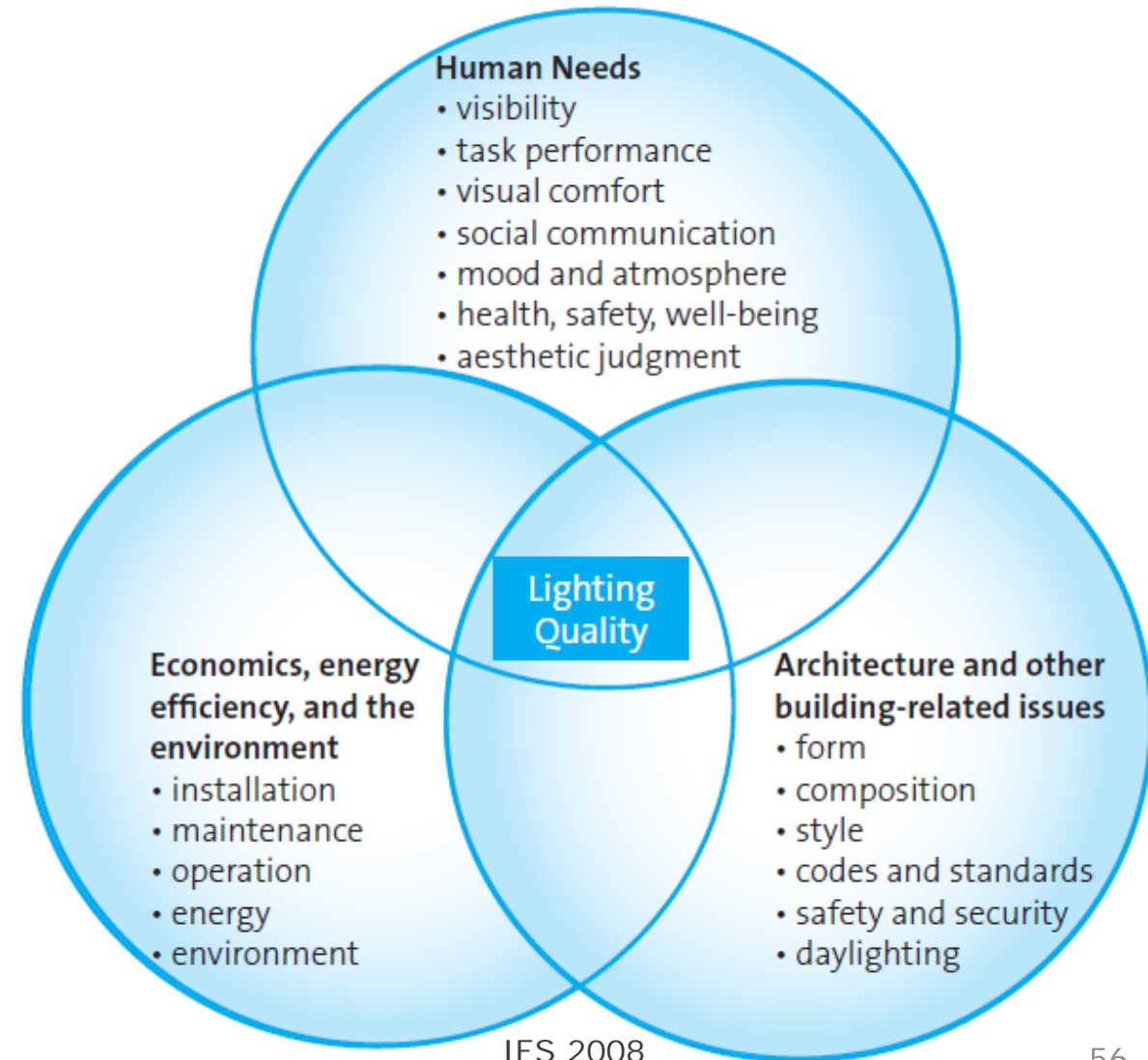
A Community Focused Lighting Approach for Outdoor Environments



Lighting Quality

(IES DG-18-08)

Lighting that positively addresses human needs, architecture, economics, energy and the environment.



Urban Lighting Realities



Photo in Cartagena by Don Slater / Configuring Light / London School of Economics

Dark, under-lit streets:

- Lack of visibility
- Fear and potential of increased accidents
- Fear and potential of increased crime
- Abandoned streets after-dark



Photo in Cartagena by Don Slater / Configuring Light / London School of Economics

Glary area flood lighting:

- Often lack of visibility (high glare, high contrast, color)
- Light trespass (sky, windows)
- Sense of surveillance and 'being watched'
- Abandoned streets after-dark



Objectives for Urban Lighting:

- Enhance community and economic development
- An organized, well-designed visual environment: aesthetics, atmosphere, and visual pleasure
- Legibility and wayfinding
- Enhanced perception of safety, reduction of the potential for (traffic) accidents
- Enhanced perception of security, reduction of the potential for crime
- Cost-effective and maintainable

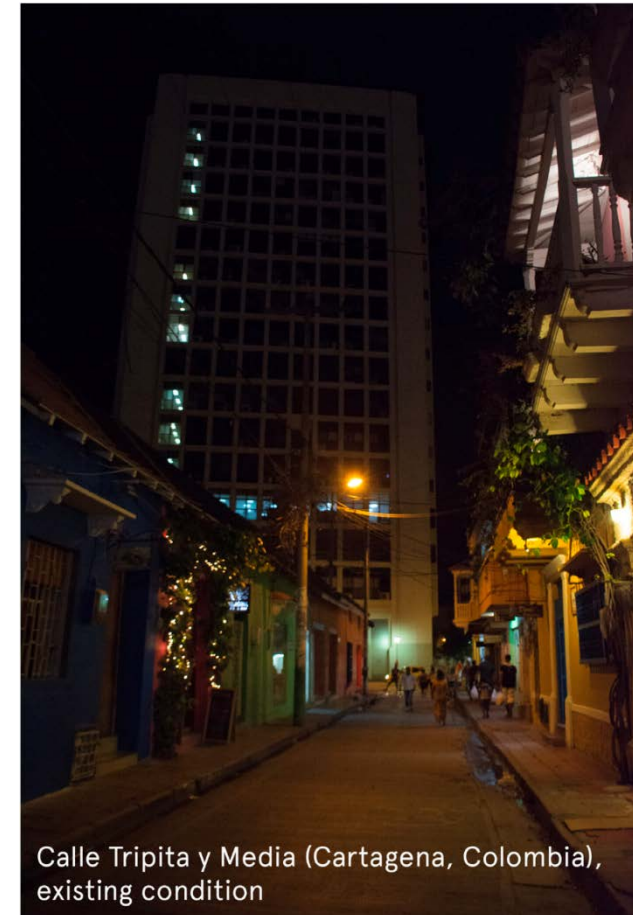
Strategies Used:

- Working with varied key stakeholders
- Stakeholder investment
- Strengthening community bonds
- Expressing authenticity and variation with light
- Utilizing and coordinating public as well as private property for urban lighting
- Using evidence-based design qualitative and quantitative research methodologies



Pilot Project:

1. Identify Stakeholders
2. NightSeeing™ and Survey Events
3. Community and Stakeholder Workshop
4. Prototype Pilot Implementation Event
5. Pilot Documentation and Evaluation
6. Pilot Assessment and Evaluation / Lessons Learned
7. Large Scale, Long-Term Implementation



Calle Tripita y Media (Cartagena, Colombia), existing condition

1. Identifying Stakeholders

- Municipalities / various city agencies
- Community members
 - Residents
 - Businesses
- Frequent visitors (commuters, tourists)
- Other interest groups, e.g.
 - Property owners
 - Public space managers
 - Workers
 - Institutions (e.g. educational, hospital)
 - City associations

2. NightSeeing™ and Survey Events

- Creating Awareness of Existing Lighting



3. Community Workshop

- Collaboration of all stakeholders

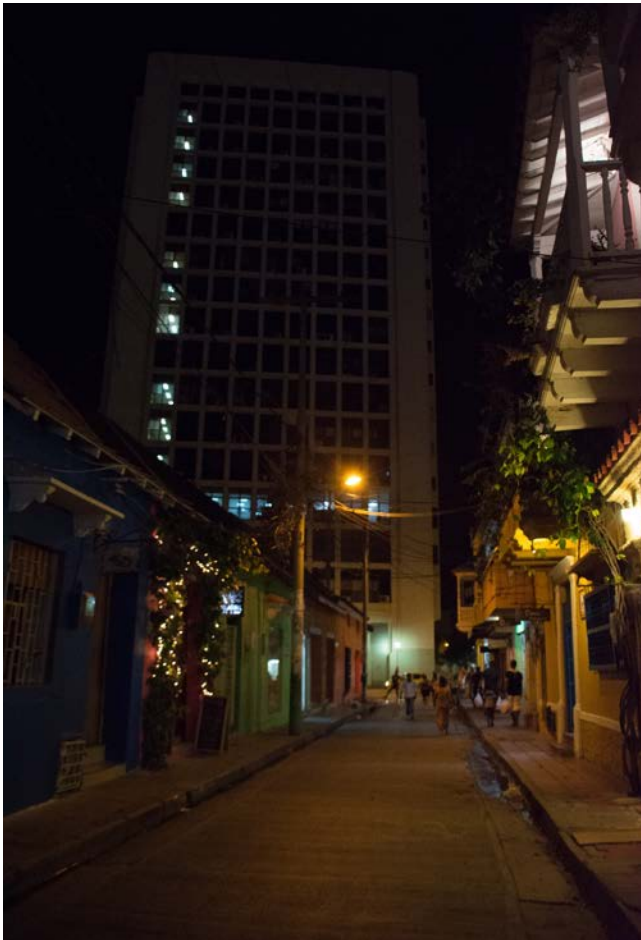


4. Community Implementation Workshop

- Encouraging and allowing personalization

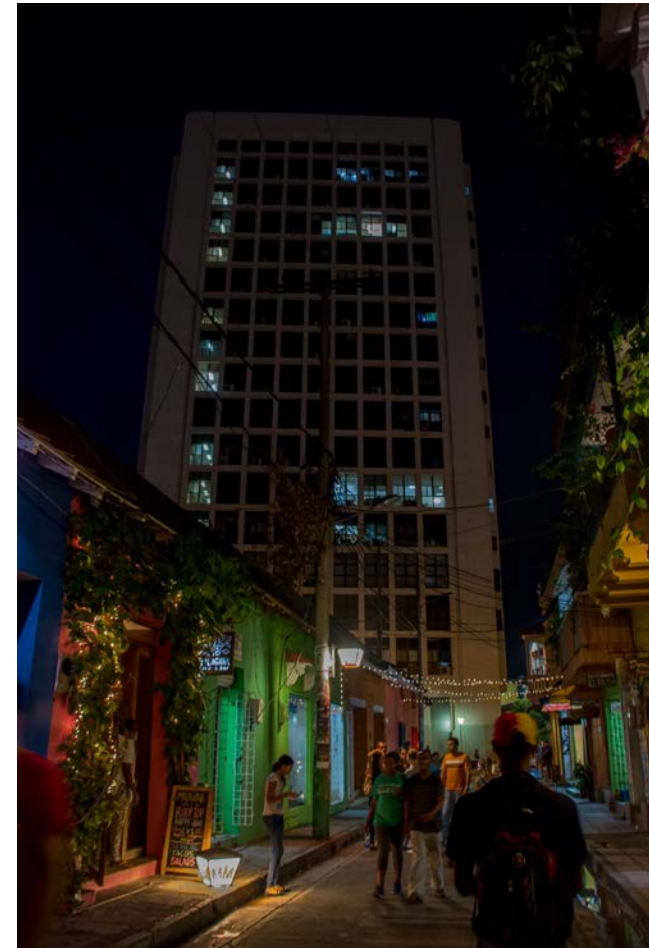


Pilot Outcome: Calle Tripita y Media, Cartagena, Colombia



Before

- Repeated 'small' lighting gestures at low building height
- Use of high quality, aesthetically compelling, durable luminaires
- De-installation of high-glare high-mounted flood lighting
- Creating consistent, comfortable street and sidewalk illumination
- Possible: smart city control grid and operation via solar and batteries

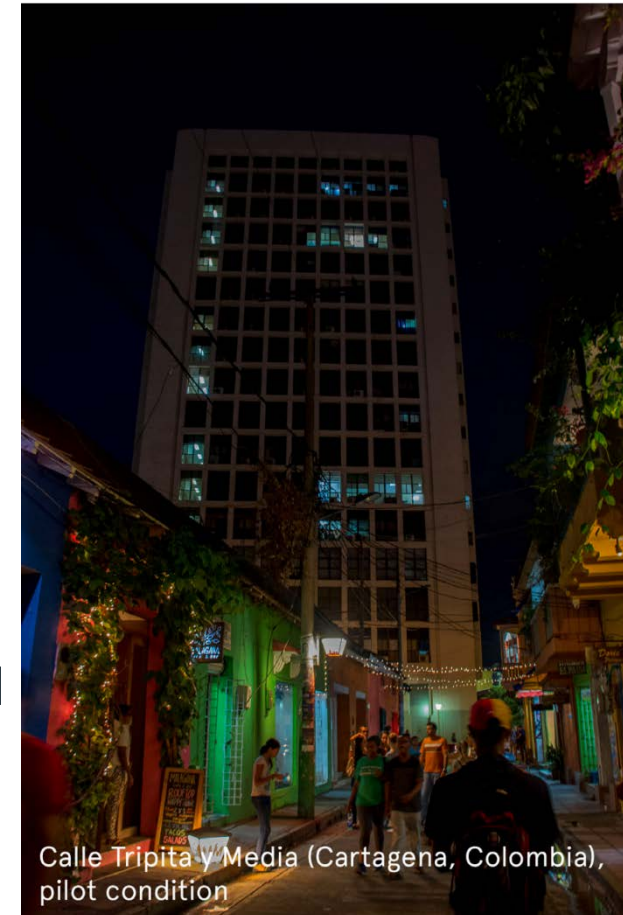


After



Pilot Project (next steps):

1. Identify Stakeholders
2. NightSeeing™ and Survey Events
3. Community and Stakeholder Workshop
4. Prototype Pilot Implementation Event
5. Pilot Documentation and Evaluation
- 6. Pilot Assessment and Evaluation / Lessons Learned**
- 7. Large Scale, Long Term Implementation**



Calle Tripita y Media (Cartagena, Colombia), pilot condition

V5.0 Quality of Light

Strengthening the focus on product characteristics that impact:

- Visibility
 - Task performance
 - Visual comfort
 - Social communication
 - Mood and atmosphere
 - Health, safety, wellbeing
 - Aesthetic judgement
- **Improving the light quality of listed products**
 - **Enabling easier product differentiation for an application**

Incorporating further reporting on 'quality of light' properties:

- Color Quality
- Glare
- Distribution
- Flicker





Thank you for your attention!

We ask for your valued:

feedback, questions, comments

regarding all aspects of outdoor lighting.



Panel Discussion



STAKEHOLDER MEETING 2018

July 9 - 11 • Boston, MA

THANK YOU