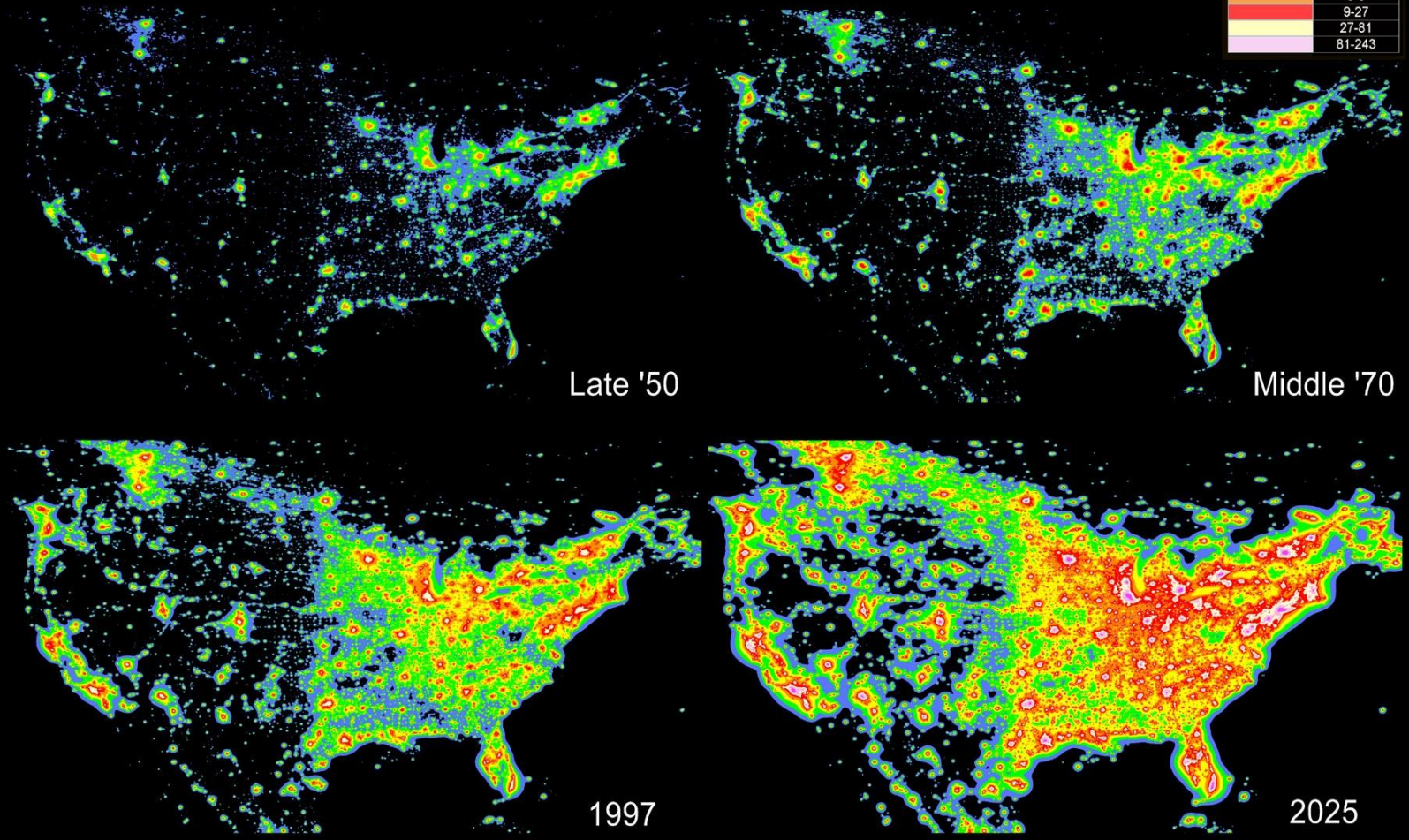
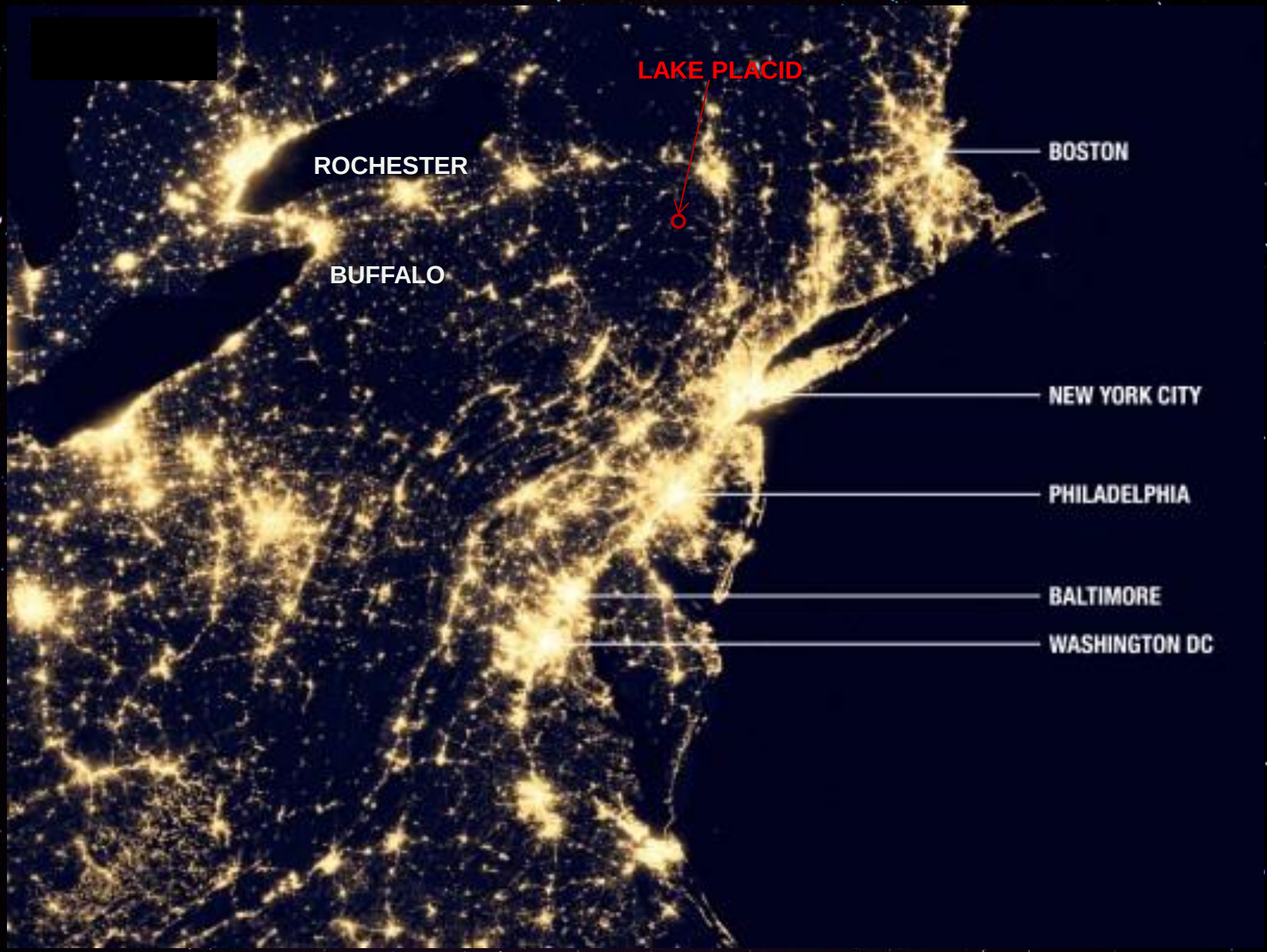
Recommended Practices for Responsible Outdoor Lighting

Light Pollution at Night

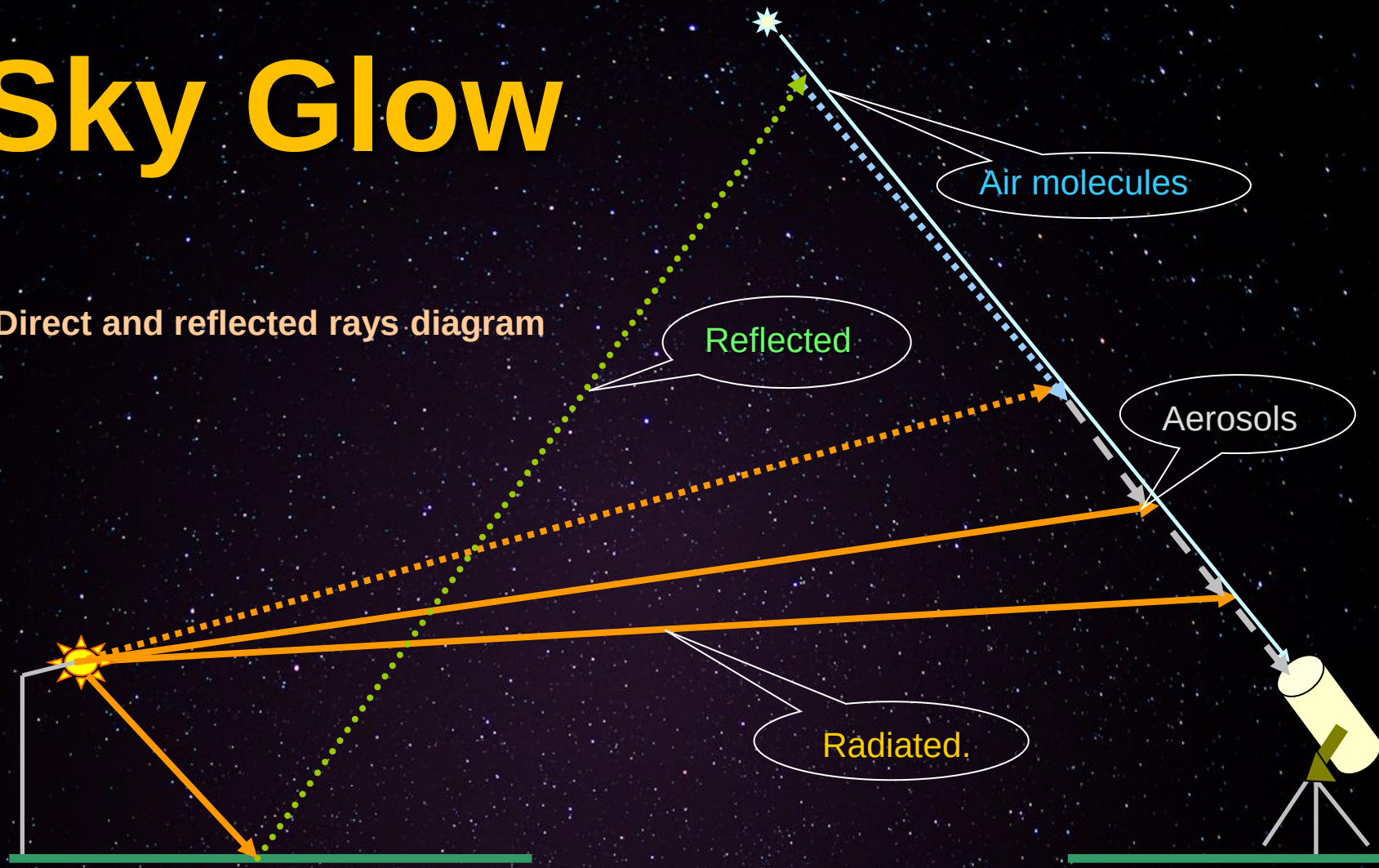
Artificial Night Sky Brightness due to Light Pollution in North America
A preliminary picture of the growth from 1950 to 2025




LAKE PLACID
ROCHESTER
BUFFALO
BOSTON
NEW YORK CITY
PHILADELPHIA
BALTIMORE
WASHINGTON DC

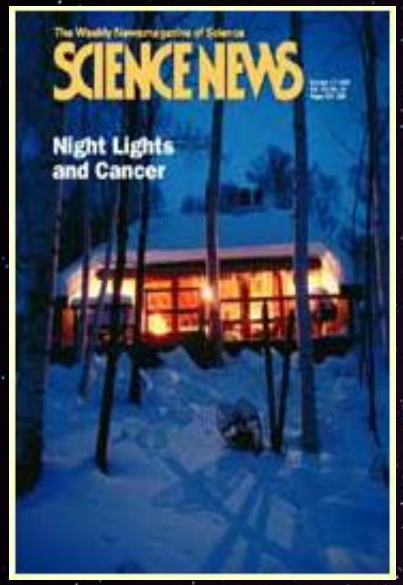
Sky Glow

Direct and reflected rays diagram



Skyglow is caused by the downward scattering of upward light by air molecules and also aerosols, mostly water droplets and dust. The longer the path length through the lowest part of the atmosphere, the more the scattering. Light that goes straight up is mostly reflected, and has shorter paths through the lower scattering layers. The low angle light is mostly directly radiated, and it is this that causes most of the sky glow well away from the source.

Electric Lighting at Night and Human Health –



Increased Risk of Breast Cancer

Breast Cancer Incidence Per 100,000 women/year (age-adjusted)

U.S. & W. Europe

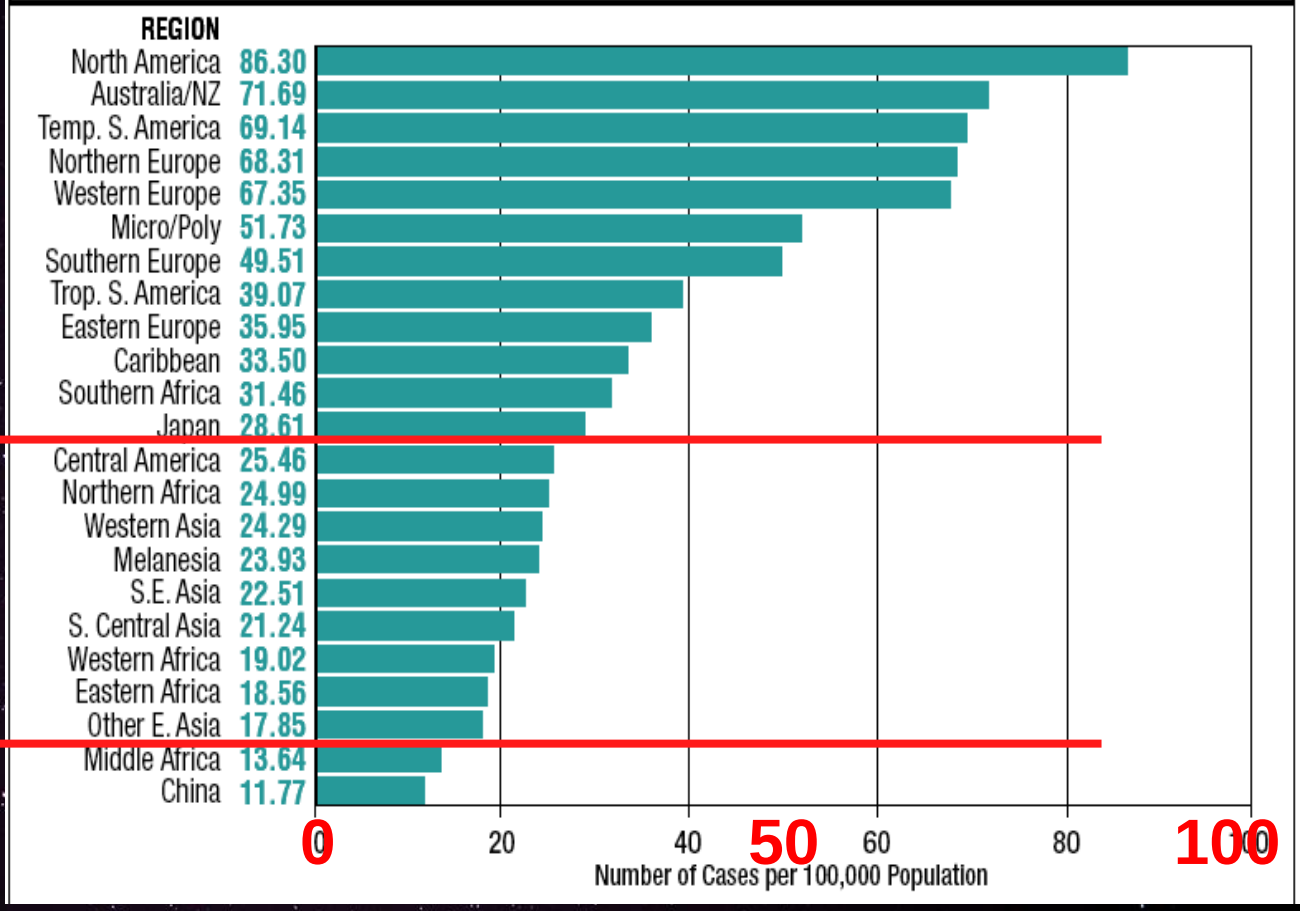
Eastern Europe

Japan (Today)

Africa

Japan, 1950s

China



From the IARC, Lyon: Parkin, DM, et al. *CA Cancer J Clin*, 49:33-64, 1999

American Medical Association 2009

- Advocates that all future outdoor lighting be of energy efficient designs to reduce waste of energy and production of greenhouse gasses that result from this wasted energy use, and be it further

- Develops and enacts a policy that supports light pollution reduction efforts and glare reduction efforts at both the national and state levels; and be it further

- Supports that all future streetlights will be of a fully shielded design or similar non-glare design to improve the safety of our roadways for all, but especially vision impaired and older drivers.

American Medical Association
LED Warning – Issued June 14, 2016

Covers Environmental Effects of Light Emitting Diode (LED) Community Lighting

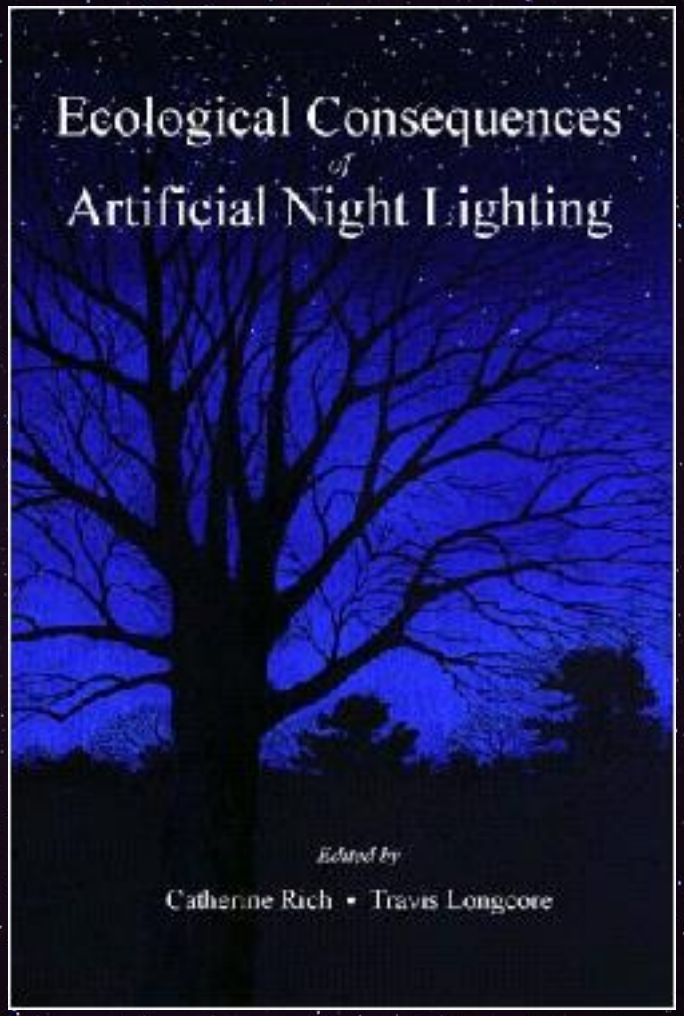
AMA encourages the use of 3000K color temperature or lower lighting for outdoor installations…(limit blue light)

All LED lighting should be properly shielded to minimize glare and detrimental human and environmental effects

Consideration should be given to dimming LED lighting for off-peak time periods

http://darksky.org/ama-report-affirms-human-health-impacts-from-leds/

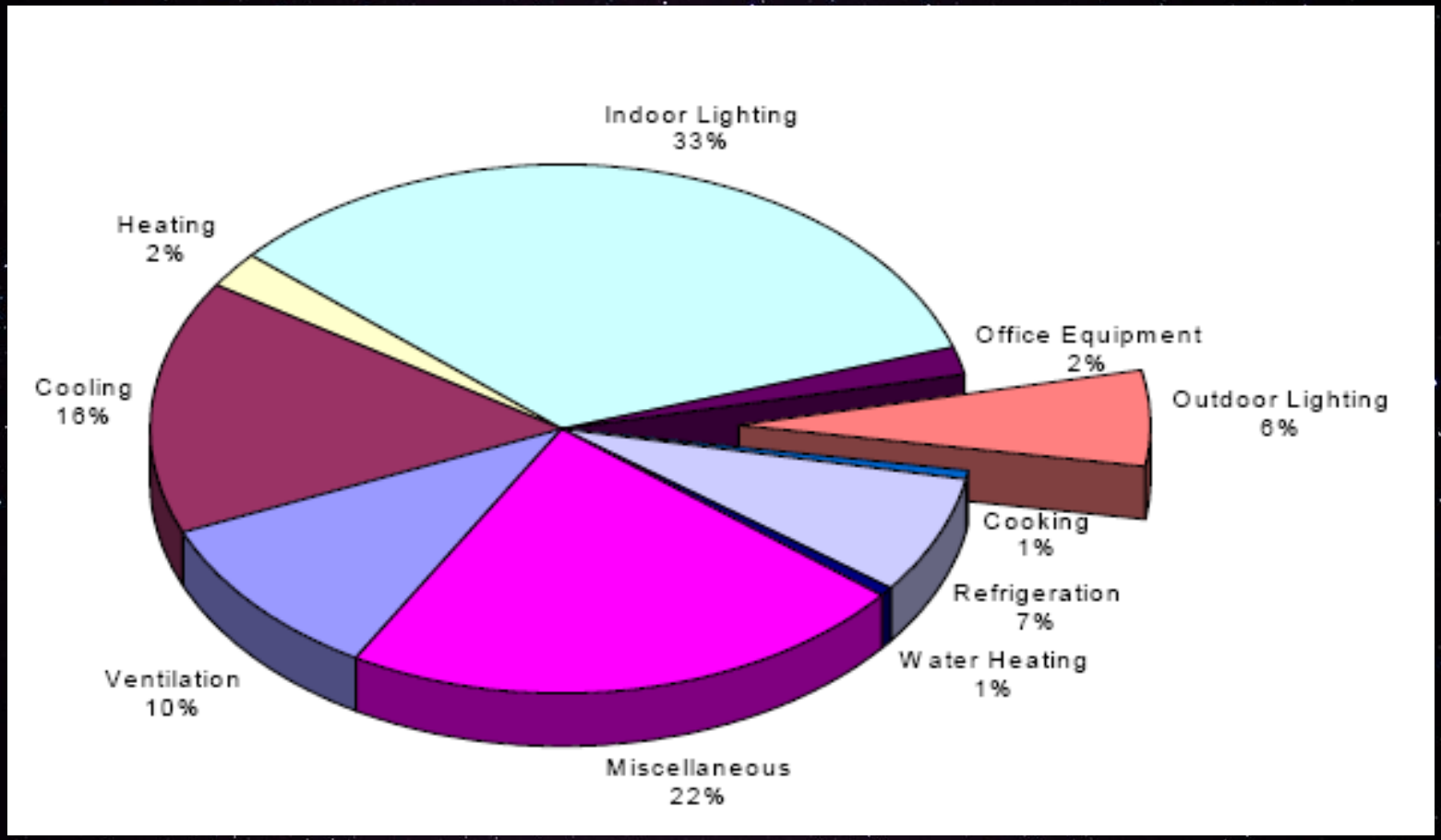
AMA 2016 Research Paper on LED Lighting was co-authored by Travis Longcore



Implementing Good Light Pollution Controls Contributes to Improving Energy Conservation

$2 Billion
In Wasted Energy!

Energy Consumed by End User
Outdoor Lighting = 6%



Energy Waste

Generation of one KWh of electricity creates 1.34 pounds of carbon dioxide waste (CO_2).

Lighting the sky with wasted uplight creates 14.7 million tons of CO_2 annually.

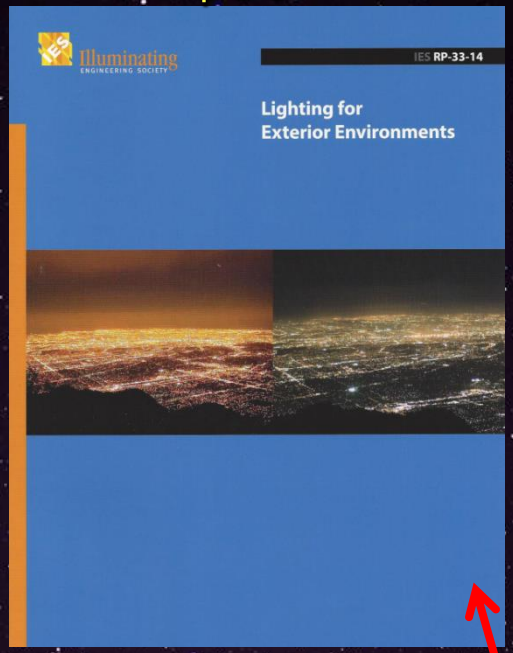
Coal needed to generate the wasted light would be about <u>3.6 million tons of per year.</u>

Outdoor Lighting Recommended Practices

No Charge

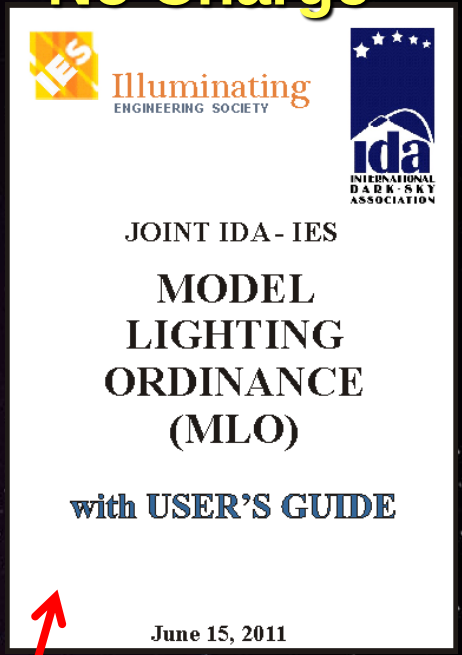
Natural Sounds and Night Skies Division

$60



RP-33 Lighting for The Exterior Environment

No Charge



Model Lighting Ordinance

Both at Illuminating Engineering Society Bookstore at IES.ORG

Best Practices for Night Skies

Light only WHERE & WHEN to the Minimum Level Needed

Shield – Point Downward – Consider Dimmer & Timer

https://www.nps.gov/subjects/nightskies/practices.htm

Wilderness Value of Night Skies

“Dark night skies are a wilderness characteristic”

“A single glaring light can reel back those seeking solitude or communion with nature…”

https://www.nps.gov/subjects/nightskies/wilderness.htm

Night Skies as a Public Resource

As a Resource of Nature

Natural darkness essential for wildlife

Nearly 50% of species are nocturnal

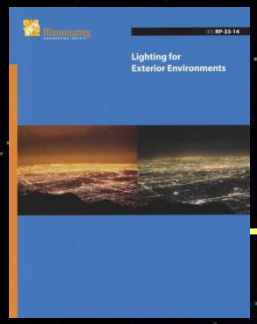
As a Cultural Resource

The same dark and starry sky has evoked countless myths, art, literature and music from cultures around the world

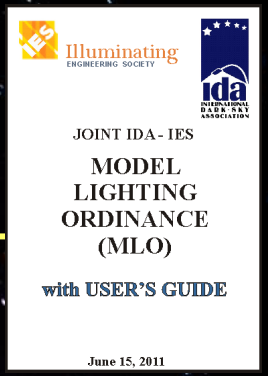
As an Economic Resource

- Astronomical/Optical Research
- Amateur Stargazing
- Wilderness Camping

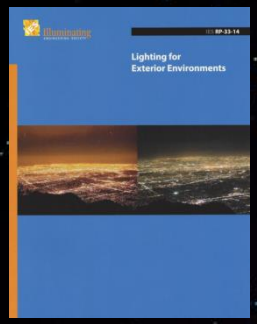
https://www.nps.gov/subjects/nightskies/resources.htm



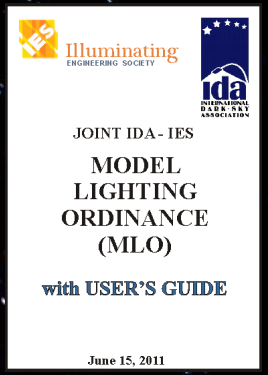
MLO and RP-33 Both Use 5 Lighting Zones



- **LZ-0** - no ambient light
  - Nature preserves, parks, trails
  - 2 acre single family residential
- **LZ-1** - low ambient light
  - All other single family residential
  - Single stand alone small business
- **LZ-2** - moderate (some) ambient light
  - Concentrated commercial downtown strip
  - Parking lot for malls or large apartment complex



Lighting Zones Continued



- **LZ-3** - moderately high ambient light
  - Concentrated commercial district
  - Major City urban core business district
  - Applies mostly to street front settings
- **LZ-4** - extremely high ambient light
  - Rare – Times Square, Las Vegas Strip

LZ-3 and **LZ-4** Ambient Light are usually limited to areas tangent to the street and sidewalk – where ambient light exists.

BUG Ratings now included as part of Luminaire Manufacturer's Photometrics – easy to check

LED Lamp Details

LED = Philips Lumileds Luxeon R, CRI = 70, CCT = 4000K (+/- 350K)
System (LED + driver) rated life = 100,000 hrs[1]

LAMP	TYPICAL DELIVERED LUMENS	TYPICAL SYSTEM WATTAGE[2] (W)	TYPICAL CURRENT @ 120V (A)	TYPICAL CURRENT @ 208V (A)	TYPICAL CURRENT @ 240V (A)	TYPICAL CURRENT @ 277V (A)	LED CURRENT (mA)	HID EQUIVALENT[3]	LUMINAIRE EFFICACY RATING (LM/W)	BUG RATING
35W32LED4K-R-LE2	3200	35	0.29	0.17	0.16	0.15	350	70 -100	91.4	B1-U0-G1
35W32LED4K-R-LE3	3200	35	0.29	0.17	0.16	0.15	350	70 -100	91.4	B1-U0-G1
35W32LED4K-R-LE4	3200	35	0.29	0.17	0.16	0.15	350	70 -100	91.4	B1-U0-G1
35W32LED4K-R-LE5	3200	35	0.29	0.17	0.16	0.15	350	70 -100	91.4	B2-U0-G1
55W32LED4K-R-LE2	4500	52	0.40	0.23	0.21	0.19	530	100 - 150	86.5	B1-U0-G1
55W32LED4K-R-LE3	4500	52	0.40	0.23	0.21	0.19	530	100 - 150	86.5	B1-U0-G1
55W32LED4K-R-LE4	4500	52	0.40	0.23	0.21	0.19	530	100 - 150	86.5	B1-U0-G1
55W32LED4K-R-LE5	4500	52	0.40	0.23	0.21	0.19	530	100 - 150	86.5	B2-U0-G1
55W48LED4K-R-LE2	5000	55	0.38	0.22	0.23	0.21	350	100 - 150	90.9	B1-U0-G1
55W48LED4K-R-LE3	5000	55	0.38	0.22	0.23	0.21	350	100 - 150	90.9	B1-U0-G1
55W48LED4K-R-LE4	5000	55	0.38	0.22	0.23	0.21	350	100 - 150	90.9	B1-U0-G1
55W48LED4K-R-LE5	5000	55	0.38	0.22	0.23	0.21	350	100 - 150	90.9	B2-U0-G1
80W48LED4K-R-LE2	7200	79	0.63	0.36	0.34	0.31	530	150-200	91.1	B2-U0-G1
80W48LED4K-R-LE3	7200	79	0.63	0.36	0.34	0.31	530	150-200	91.1	B2-U0-G1
80W48LED4K-R-LE4	7200	79	0.63	0.36	0.34	0.31	530	150-200	91.1	B2-U0-G1
80W48LED4K-R-LE5	7200	79	0.63	0.36	0.34	0.31	530	150-200	91.1	B3-U0-G1
70W64LED4K-R-LE2	6200	71	0.58	0.34	0.32	0.3	350	100 - 150	87.3	B2-U0-G1
70W64LED4K-R-LE3	6200	71	0.58	0.34	0.32	0.3	350	100 - 150	87.3	B2-U0-G1
70W64LED4K-R-LE4	6200	71	0.58	0.34	0.32	0.3	350	100 - 150	87.3	B2-U0-G1
70W64LED4K-R-LE5	6200	71	0.58	0.34	0.32	0.3	350	100 - 150	87.3	B3-U0-G1
110W64LED4K-R-LE2	9300	103	0.80	0.46	0.42	0.38	530	200 - 250	90.3	B2-U0-G2
110W64LED4K-R-LE3	9300	103	0.80	0.46	0.42	0.38	530	200 - 250	90.3	B2-U0-G2
110W64LED4K-R-LE4	9300	103	0.80	0.46	0.42	0.38	530	200 - 250	90.3	B2-U0-G2
110W64LED4K-R-LE5	9300	103	0.80	0.46	0.42	0.38	530	200 - 250	90.3	B4-U0-G2
90W80LED4K-R-LE2	8600	87	0.78	0.43	0.40	0.34	350	150-200	98.9	B2-U0-G2
90W80LED4K-R-LE3	8600	87	0.78	0.43	0.40	0.34	350	150-200	98.9	B2-U0-G2
90W80LED4K-R-LE4	8600	87	0.78	0.43	0.40	0.34	350	150-200	98.9	B2-U0-G2
90W80LED4K-R-LE5	8600	87	0.78	0.43	0.40	0.34	350	150-200	98.9	B4-U0-G2
135W80LED4K-R-LE2	12000	129	1.15	0.61	0.58	0.5	530	250 - 320	93.0	B2-U0-G2
135W80LED4K-R-LE3	12000	129	1.15	0.61	0.58	0.5	530	250 - 320	93.0	B2-U0-G2
135W80LED4K-R-LE4	12000	129	1.15	0.61	0.58	0.5	530	250 - 320	93.0	B2-U0-G2
135W80LED4K-R-LE5	12000	129	1.15	0.61	0.58	0.5	530	250 - 320	93.0	B4-U0-G2

BUG RATING
B1-U0-G1
B1-U0-G1
B1-U0-G1
B2-U0-G1
B1-U0-G1
B1-U0-G1
B1-U0-G1
B2-U0-G1
B1-U0-G1
B1-U0-G1

Controlling Color Temperature - (LED)

Limit maximum color temperature to 2,700K (warm white)

2,700K – Warmer – more inviting – less blue

5,000K and above – more bluish – colder – creates more light pollution

Table 1. Selected blue light characteristics of various outdoor lighting sources at equivalent lumen output.

Row	Light source	CCT (K)	% Blue*	Luminous Flux (lm)	Scotopic content relative to HPS	Melanopic content relative to HPS**
A	PC white LED	2700	17% - 20%	1000	1.77 - 1.82	1.90 - 2.06
B	PC white LED	3000	18% - 25%	1000	1.89 - 2.13	2.10 - 2.51
C	PC white LED	3500	22% - 27%	1000	2.04 - 2.37	2.34 - 2.97
D	PC white LED	4000	27% - 32%	1000	2.10 - 2.65	2.35 - 3.40
E	PC white LED	4500	31% - 35%	1000	2.35 - 2.85	2.75 - 3.81
F	PC white LED	5000	34% - 39%	1000	2.60 - 2.89	3.18 - 3.74
G	PC white LED	5700	39% - 43%	1000	2.77 - 3.31	3.44 - 4.52
H	PC white LED	6500	43% - 48%	1000	3.27 - 3.96	4.38 - 5.84
I	Narrowband amber LED	1606	0%	1000	0.36	0.12
J	Low pressure sodium	1719	0%	1000	0.35	0.10
K	PC amber LED	1872	1%	1000	0.70	0.42
L	High pressure sodium	1959	9%	1000	0.89	0.86
M	**High pressure sodium**	**2041**	**10%**	**1000**	**1.00**	**1.00**
N	Incandescent	2851	12%	1000	2.26	2.79
O	Halogen	2934	13%	1000	2.28	2.81
P	F32T8/830 fluorescent	2940	20%	1000	2.02	2.29
Q	Metal halide	3145	24%	1000	2.16	2.56
R	F32T8/835 fluorescent	3480	26%	1000	2.37	2.87
S	F32T8/841 fluorescent	3969	30%	1000	2.58	3.18
T	Metal halide	4002	33%	1000	2.53	3.16
U	Metal halide	4041	35%	1000	2.84	3.75

* Percent blue calculated according to LSPDD: Light Spectral Power Distribution Database, http://galileo.graphycs.cegepsherbrooke.qc.CA/app/en/home. The specific calculation, developed for evaluating the potential for affecting sky glow, divides the radiant power contained in the wavelengths between 405 and 530 nm by the total radiant power contained from 380 to 780 nm, for each light source.

** Melanopic content calculated according to CIE Irradiance Toolbox, http://files.cie.co.at/784_TN003_Toolbox.xls, 2015 as derived from Lucas et al., 2014.

Key: PC -- Phosphor Converted; LED -- Light Emitting Diode

http://energy.gov/sites/prod/files/2016/07/f33/msslc_enews_jul2016.pdf

Maximize Energy Efficiency & Minimize Costs

Dimmers and Network Devices with new LED lighting systems reduce energy use

Curfews for Lights Out – reduced to 30% of full capacity after the close of business and pedestrian activity

Motion activation for commercial interior lighting after business hours

LED lighting systems for new and replacement lighting.

Dimming a little from full capacity extends life of the system. Purchase system with a slightly higher light output than is required, then dim down to the light level needed for the project to extend equipment life.

Key Considerations for Replacing older Outdoor Lights with LEDs

- **Specify the maximum CCT** at preferably 2,700K – no more than 3,000K – minimize blue light levels
- **Fixture lumen output** of LED can by 50% of High Pressure Sodium's fixture output and achieve the same visibility to the eye.
- **Choose a luminaire with a light output** that will be about 30% greater than what is needed – then using a dimmable lighting system, dim the lights down 30%. This dimming will considerably extend the life of the light compared to having the light operating at 100% output – Extended life reduces maintenance costs.

Outdoor Lighting Issues and Solutions

SHIELDING/GLARE

Controlling Light Trespass and Sky Glow

BRIGHTNESS

Controlling Light (Lumen) Levels

CORRELATED COLOR TEMPERATURE - LED

Limiting CCT to 2,700K (warm white)

ENERGY EFFICIENCY

Mandating the Use of Dimmers and Timing devices for new LED Lighting systems

DIM and USE TIMERS where possible

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Thank you!