

# Light Pollution: Wasting Energy in Ann Arbor

## A2 Dark Sky Group:

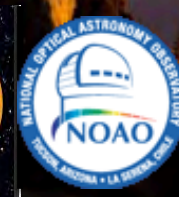
UM Astronomy  
University Lowbrow Astronomers  
UM Student Astronomical Society  
EMU Physics and Astronomy  
Washtenaw Safe Passage  
Detroit Audubon Safe Passage

Sally Oey

University of Michigan,  
American Astronomical Society

with help from IDA, NOAO,  
and J. Lowenthal

(Smith College, AAS Cmte on Light Pollution)





# Nightscape: now

80% of people live in urban areas



# What is light pollution?

- It is wasted light that performs no function or task

Light = Energy

Wasted Energy





# ENERGY WASTE

What is light pollution costing us?



**13%** of residential electricity use in the U.S. is for outdoor lighting



Average House

Bad outdoor lighting wastes **0.5 kilowatt-hours (kWh)** of energy per house, per night

**0.5 kWh** of electricity

= enough energy to power a 50-inch plasma TV for 1 hour



About **35%** of light is wasted by unshielded and/or poorly-aimed outdoor lighting

## SKYGLOW

is the artificial brightness of the night sky that's caused by light pollution.

This is about **\$3 BILLION** per year worth of energy lost to skyglow



Which is about **\$10.00**

spent for every man, woman, and child in the U.S. every year

About **15 million** tons of CO<sub>2</sub> are emitted each year in order to power residential outdoor lighting in the U.S.

CO<sub>2</sub>

About **3 million** passenger cars have the same CO<sub>2</sub> emission rate, which is 40,000 tons per day.

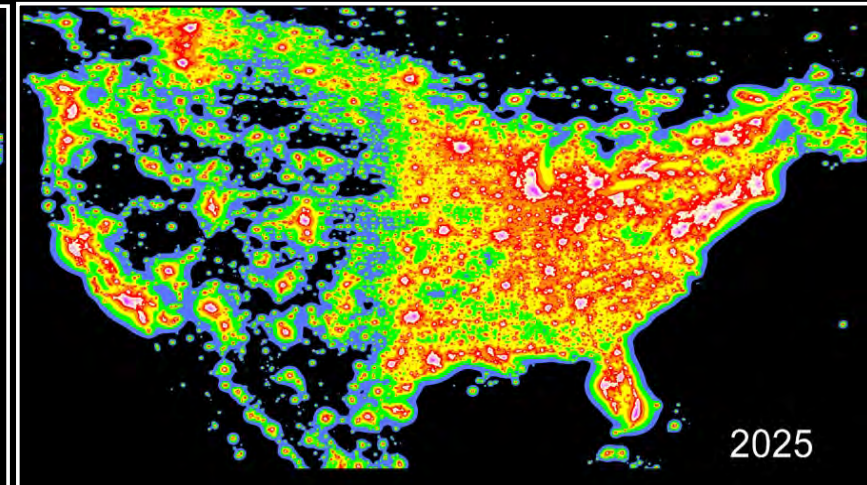
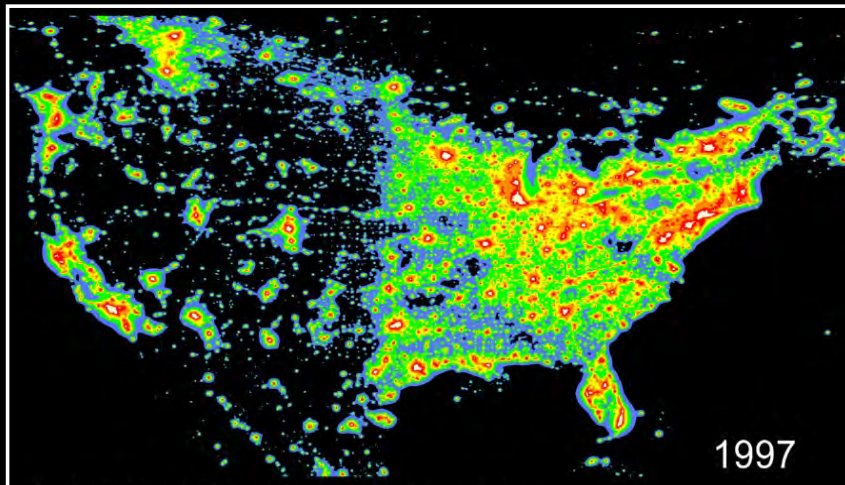
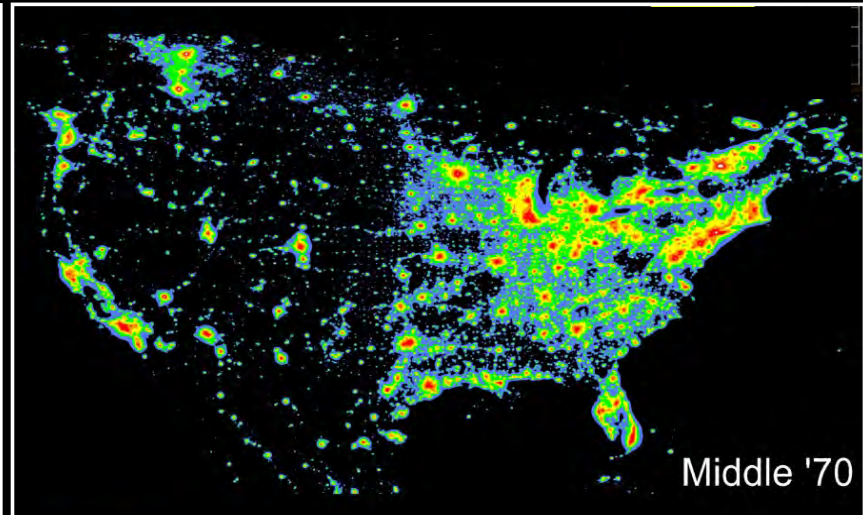


About **600 million** trees would need to be planted to offset that amount of carbon emission



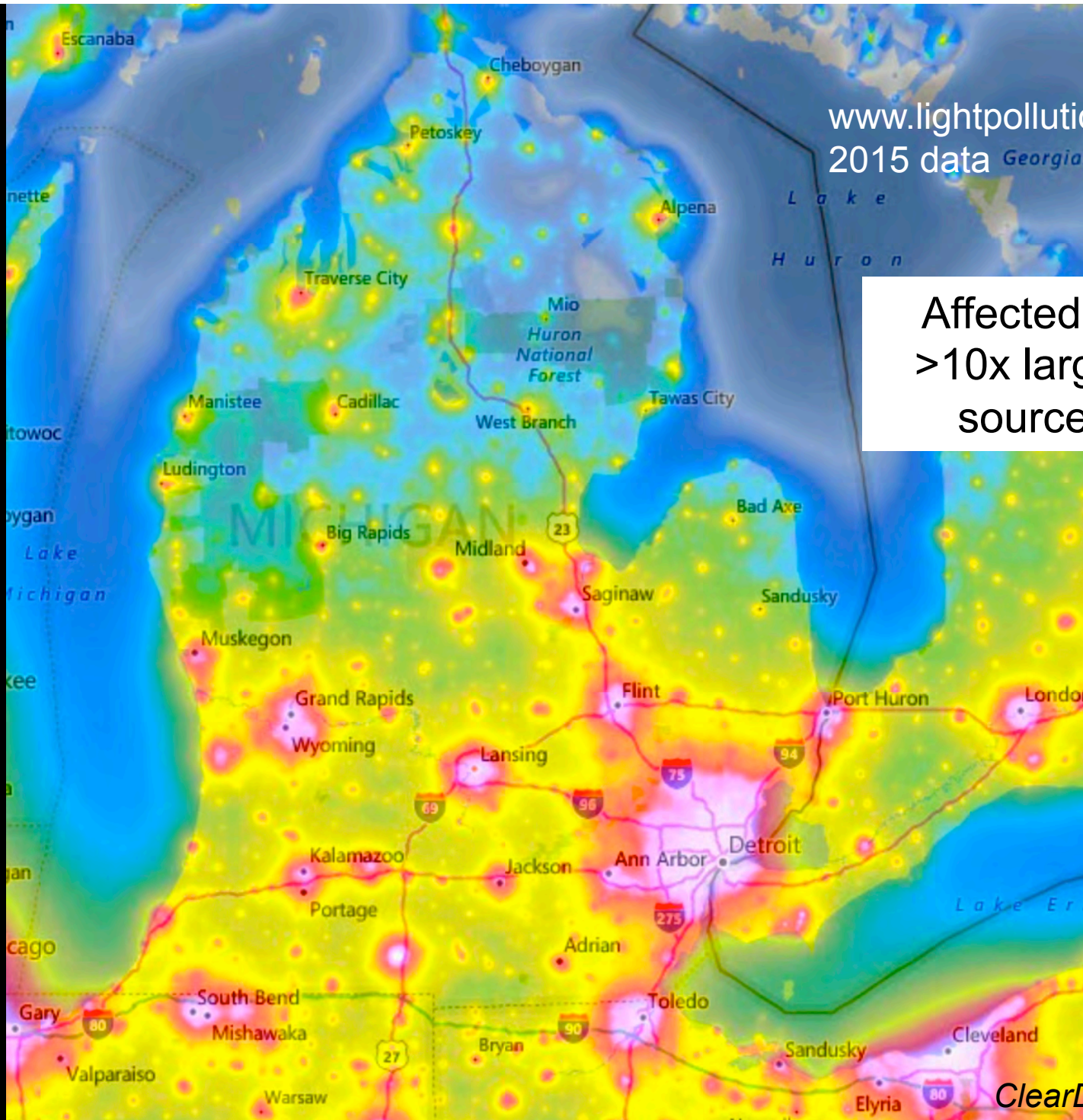


# Increasing rate up to 20% / yr (Hoelker et al. 2010)



*Cinzano, Falchi, and Elvidge (2001)*





[www.lightpollutionmap.info](http://www.lightpollutionmap.info)  
2015 data

Affected area is  
>10x larger than  
source area

# Negative Impact on Biology

- 24-hr circadian rhythm, and melatonin production, is disrupted by **artificial light at night (ALAN)**.



The Nobel Prize in Physiology or Medicine 2017  
Jeffrey C. Hall, Michael Rosbash, Michael W. Young

“for their discoveries of molecular mechanisms  
controlling the circadian rhythm”

- **ALAN** disrupts the ecosystem.

Yspi: 1 building, 1 day



- Building collisions are #1 cause of bird death
- Birds migrate at night
- Up to a billion birds killed annually

- ✓ Washtenaw Safe Passage
- ✓ Safe Passage Great Lakes, Detroit Audubon Society
- ✓ Fatal Light Awareness Program (FLAP), Toronto
- ✓ Chicago Lights Out Program



- Nocturnal pollinators
- Insects
- Bats
- Sea Turtles
- Fish, incl salmon
- ... and many more



# American Medical Association

## Report of the Council on Science and Public Health (2016)

*... some evidence supports a long-term increase in the risk for **cancer, diabetes, cardiovascular disease and obesity** from chronic sleep disruption or shiftwork and associated with exposure to brighter light sources in the evening or night.*

*... excessive blue wavelength. This feature further contributes to **disability glare**, i.e., visual impairment due to stray light, as blue wavelengths are associated with more scattering in the human eye, and sufficiently intense **blue spectrum damages retinas**.*

*It is well known that unshielded light sources cause pupillary constriction... This leads to worse vision than if the light never existed at all, defeating the purpose of the lighting fixture.*

# Astronomy: Our Connection to the Universe

- A fundamental science
- The night sky is the only astronomical lab of its kind
- Tech transfer
- Science education



BEYOND  
INTERNATIONAL YEAR OF  
ASTRONOMY

Northern Michigan



# 3 Types of Light Pollution:



## Glare

## Light Trespass



## Sky glow

# Glare reduces visibility



More light  $\neq$  more safe





More light ≠ more safe





More light ≠ more safe



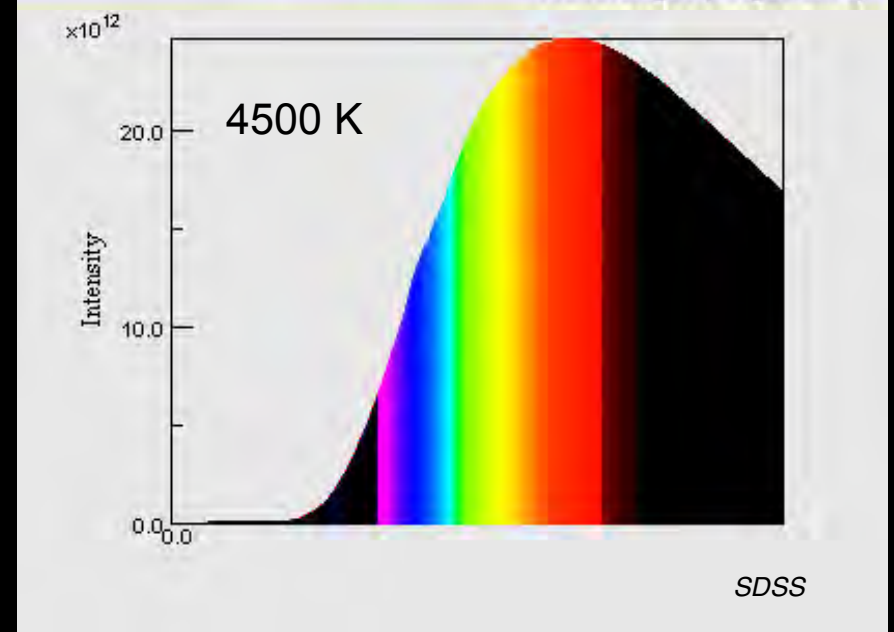
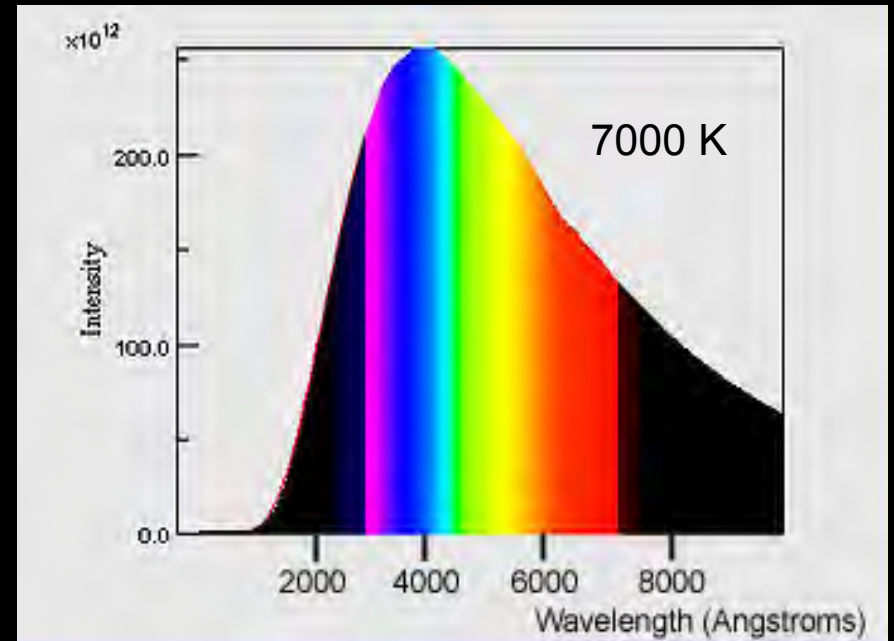
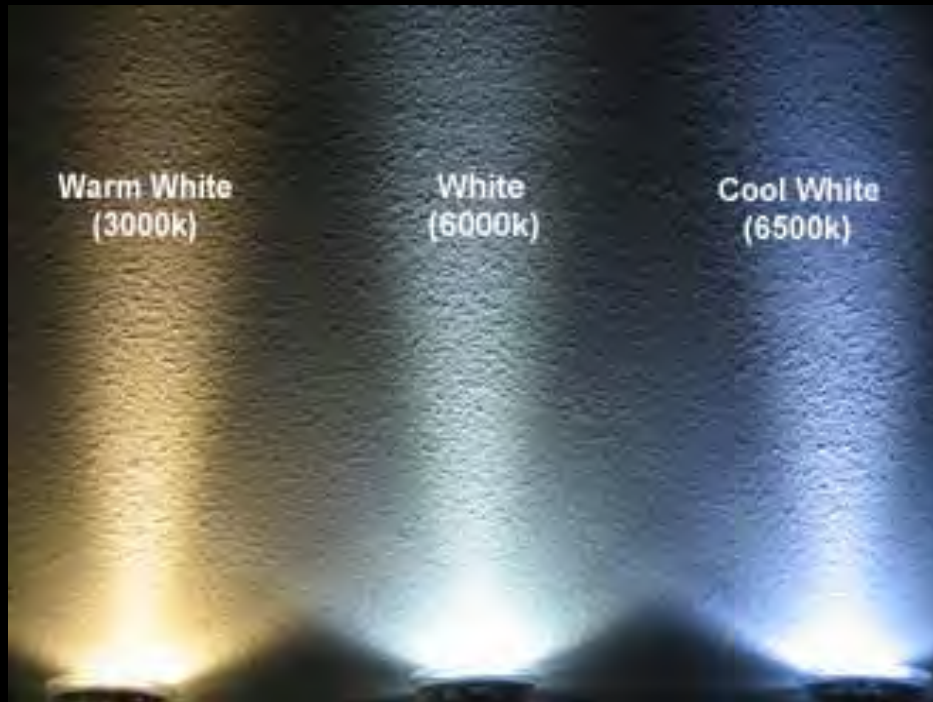
# Stage Lighting

- Visible and safe? or vulnerable and exposed?
- Eye dark adaption compromised



**More light  $\neq$  more safe**

# Color temperature





Ideally < 2500 K

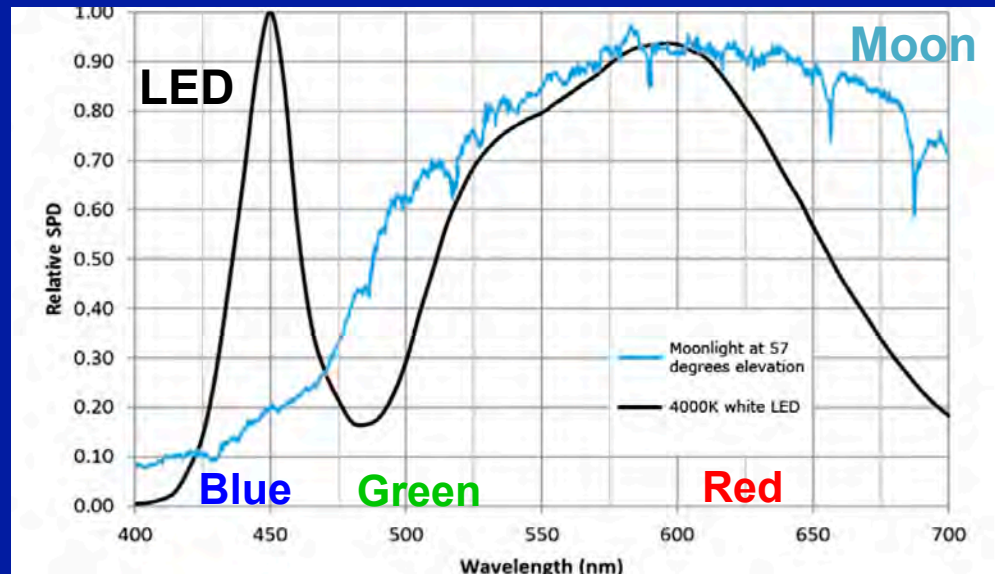
# Color temperature should be < 3000 K

- Blue light scatters far more strongly  
 $\lambda^{-4}$ : 500 nm scatters 2x more than 600 nm
- Causing more glare
- Blue destroys night vision more than red
- Blue light causes **3-5x more light pollution** than fully shielded, high-pressure sodium

*It is estimated that white LED lamps have five times greater impact on circadian sleep rhythms than conventional street lamps.*

--- American Medical Association, June 14, 2016

## Caution: color temp can be misleading



Both have Correlated Color Temperature", CCT = 4000 K

To match thermal spectrum, Color Rendering Index CRI = 100

**Blue light scatters more!**

**Different species see different color equivalencies**



# Solutions are easy!

- **Light only what is needed**
- **Light no more than needed**
- **Light only when needed**

*Smart lighting, not more lighting*

# Brightness is exponential

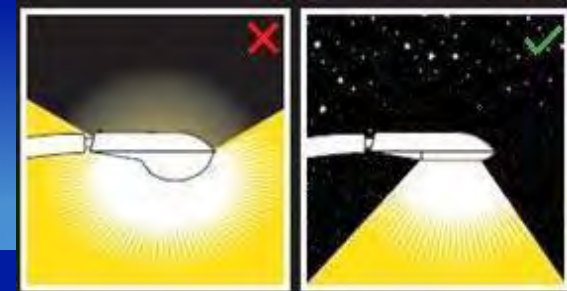
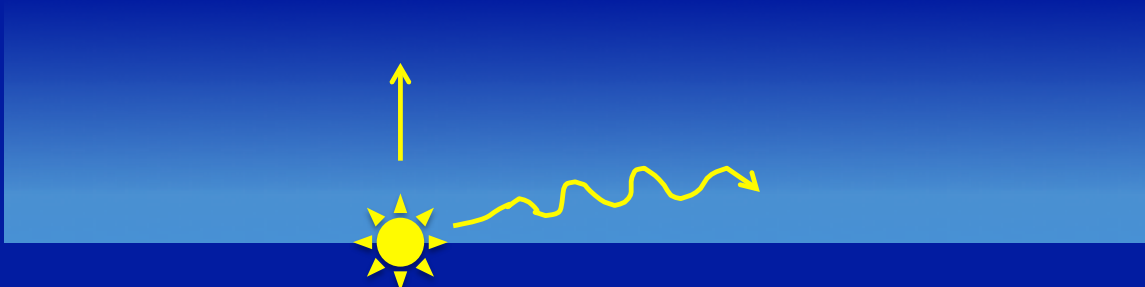
NOAO

**Full cutoff**  
**shielding is essential!**

i.e., zero uplight

Oblique upward angles  
scatter more than vertical!

Condition	Illumination
	( <i>ftcd</i> )
Sunlight	10,000
Full Daylight	1,000
Overcast Day	100
Very Dark Day	10
Twilight	1
Deep Twilight	.1
Full Moon	.01
Quarter Moon	.001
Starlight	.0001
Overcast Night	.00001





# Outdoor lighting should...

- Enhance visibility, not impede it
- Contribute to a nightscape, not dominate it
- Have a Master Plan

Good lighting design:  
No glare, trespass



# Outdoor lighting should...

- Provide safety for traffic and in areas where needed
- Facilitate use of outdoor spaces

UM Palmer Field Tennis Courts:  
Light pollution from globes,  
not from fully shielded court lights







Good

Not good

B. Greaves



Bad



PURE MICHIGAN®

- 1200 people signed Ford Field petition



M. Dalal

<http://www.freep.com/story/news/local/michigan/2017/03/04/stars-light-pollution/98638932/>



**SUSAN SELASKY**  
Grandmas know how to do Sunday dinner right  
FEAST, 1D

**MARCH4TRUMP**  
Supporters rally across state, nation for president  
METRO, 4A

**45 39**  
High Low  
**PRETTY DAY, BUT RAIN COMING**  
FORECAST, 2A

**INDEX**

Bridge	21	Horoscope	3D
Business	18	My Best Life	1D
Classics	2A	Lottery	2A
Death	18A	Music	4A
Free Press	Music	4A	
Health	15A	Puzzles	2-3L
Local News	22A	Real Estate	1F
Obituary	1E	Sports	1C
Entertainment	1E	Traffic	6E

98 MI. News 17  
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# LET THERE BE STARLIGHT

Preserving dark night skies necessary for humans, animals

**By Keith Matheny**  
Detroit Free Press

As Charles Nielsen looks skyward, he's both enthralled by, and doesn't like, what he sees.

Nielsen is president of the University Lowbrow Astronomers Club in Ann Arbor, amateur stargazers who, since the 1970s, have run an observatory on Peach Mountain in rural Dexter Township, as well as their own, large telescope. Nielsen is just as dazzled by the heavens as he has ever been, but it takes travel to dwindling, remote locations to get the great views of yesteryear.

"There would have been a time that even in downtown Ann Arbor, you would have been able to see the Milky Way," a cloudy band in the night sky from the glow of millions of stars, part of the galaxy in which our solar system resides, he said. "You have to get to a fairly dark site now to see it."

For many in southeast Michigan, starry evening skies are just a childhood memory. As cities grew, so did the bright, artificial light they put

**See STARS, Page 14A**

## Would you be for wall j car pi

Vehicles sold \$2,500 more

Proposals for a bus with Mexico and facturing in the thousands of dollars to truck sold here, includ

**MARK PHELAN**

the umbrella group for firms representing 1,000 Analysts, association could add \$2,000 to \$2,1 vehicle sold in the U.S. "This is a price men

## MDOT to build that las

Cost-effective pilot projects

**By Paul Egan**  
Detroit Free Press

LANSING — Didn't th It's a common c motorists when they et familiar location.

The Michigan Depa now trying to find out v build better roads that

Most Michigan Free life. In pilot projects th build stretches of road years, respectively.

Not only should the tal stretches of road but ties are expected to pr require less maintenance. But they won't come





22 member amateur clubs in SE MI



“Astronomy at the Beach”



One of the largest amateur astronomy communities in the US



# HEADLANDS

International Dark Sky Park



- 6<sup>th</sup> IDA Dark Sky Park, 2011
- Near Mackinaw City
- Emmet County Park
- Founded by non-astronomers
- State of Michigan  
*Pure Award 2017*
- IDA Prize:  
*Best Dark Sky Place 2017*



# 6 MI State Parks are Dark Sky Preserves



# Lighting Regulations

- Detroit
- Scio Township
- Brighton Township
- State of Michigan Dark Sky Preserves 2012, 2016
- Safe Passage Great Lakes Days

Mar 15 – May 31, and Aug 15 – Oct 31

- Ann Arbor Resolution 2009
- State of Michigan, Governor's Proclamation 2012





Light pollution control is consistent with City of A2 sustainability initiatives.



# Ann Arbor

Pioneering, award-winning LED conversion pilot project, 2006 – 2011

- Savings 850,000 kWh = \$180k / yr
- 2007 ICLEI Climate Innovation Invitational Award
- 2009 Energy Globe, US award
- National press: *NYT*, *Nat Geo*

“Glaring” omission:  
Light pollution!





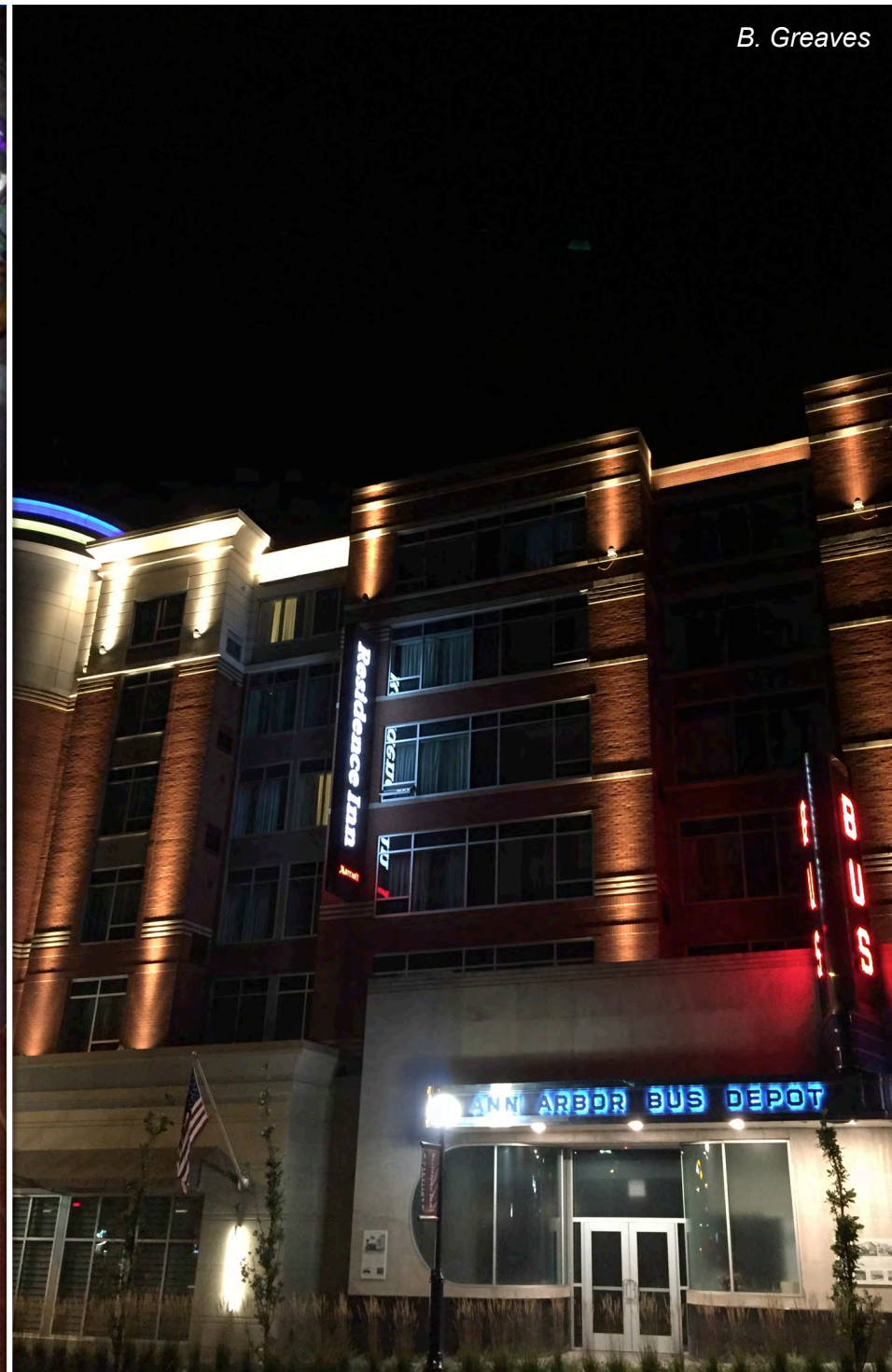


Washington / 4th St.

"Downward facing" LED globes

Upward pointing  
light on parking  
structure

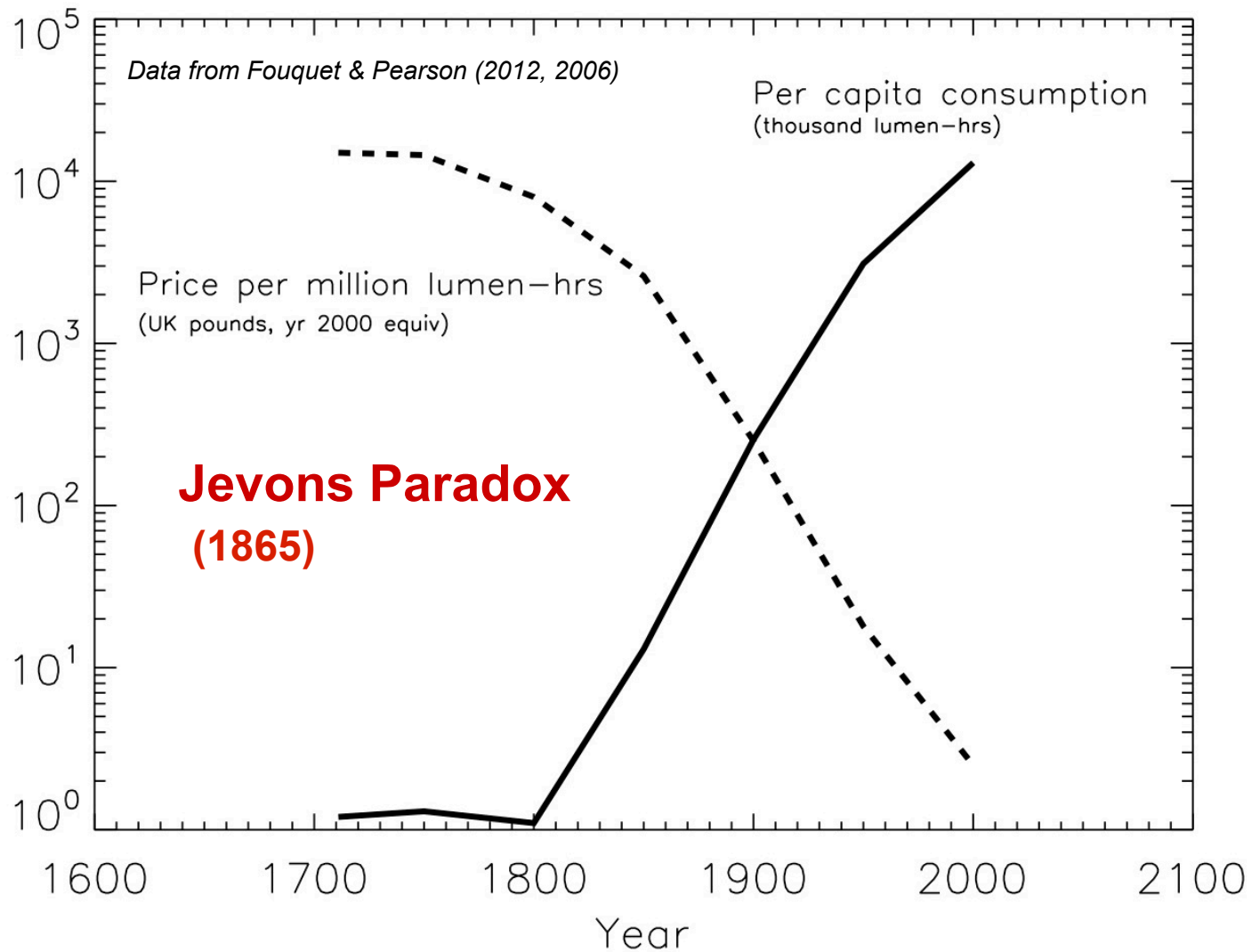
B. Greaves





# Will we really save Energy?

**Increased energy efficiency causes  
*greater* energy consumption!**



# Ann Arbor

Multiple Dark Skies initiatives over ~15+ years:

- University Lowbrow Astronomers ~2003
- Safe Passage Great Lakes Days 2009
- Burns Park trial ~2012
- Burns Park discussion 2016
- Current initiative 2017

LED Project Executive Summary (2011):

*...Finally, because LEDs emit directional light, we have more control over what we light (streets and sidewalks) and what we don't (the night sky). **This makes for easier compliance with the Dark Skies Initiative**, which aims to reduce light pollution and its associated wildlife impacts.*



- City of Ann Arbor Climate Action Plan (2012) – **no mention:**

*EB-4: Promote the use of efficient lighting technologies for both outdoor and indoor applications*

- Resolution to proceed with major project to replace pedestrian globe lights (2017)

- Revision to Zoning Code (2017):

*(5) (a) Buildings and additions constructed after the effective date ...in the downtown character overlay zoning districts ...shall comply with the following building design requirements:*

*1. ...*

*2. A minimum of 60% of the street-level facade shall be transparent windows or glazing.*



HOOPER HATHAWAY P.C.

422



# Needed

1. Inclusion of light pollution control in A2 Climate Action Plan
2. City Ordinance to control light pollution
3. City lighting audit and environmentally responsible Lighting Plan
4. Modification of globe light specs to specify *max* color temp and *max* lumen output
5. ... ??



# Controlling Light Pollution:

Develop a responsible plan to:

light only what is needed, no more than needed,  
and only when needed.

- Save energy
- Restore natural environment and habitat
- Improve health
- Improve safety
- Reconnect with the night sky

Supports A2 and Michigan values