

The background of the slide is a reproduction of the painting 'The Starry Night' by J.M.W. Turner. It depicts a turbulent, swirling night sky with a prominent crescent moon and numerous stars, each surrounded by a halo of light. In the foreground, a dark, jagged cypress tree stands on the left, and a small village with a church spire is visible in the distance under the swirling blue and white sky.

# Light Pollution in Kirksville

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& Ingrid Roettgen

Truman State University & Moberly Area Community  
College

MARAC Conference

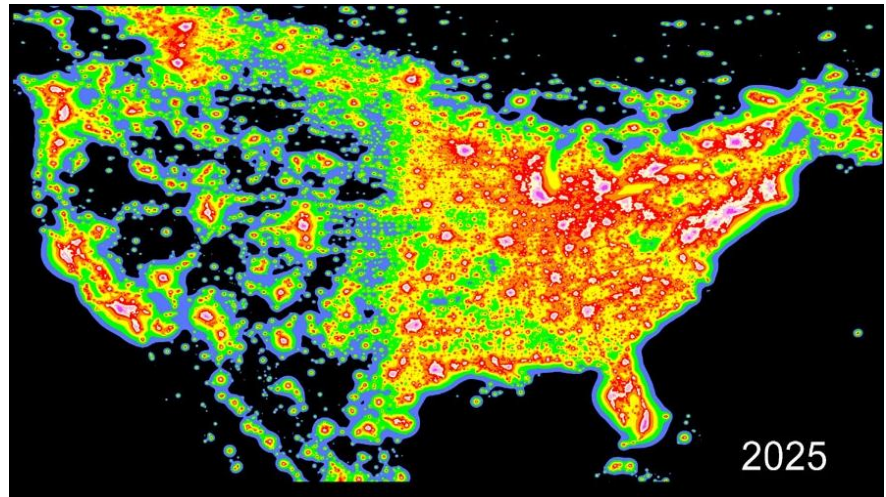
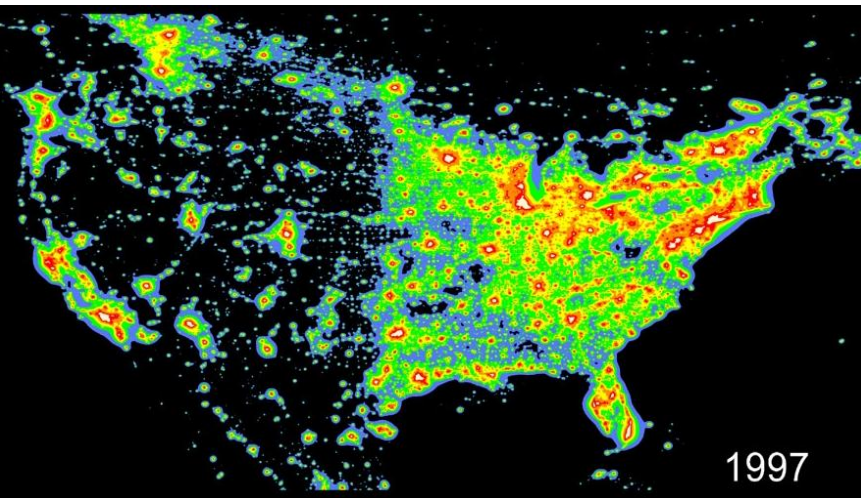
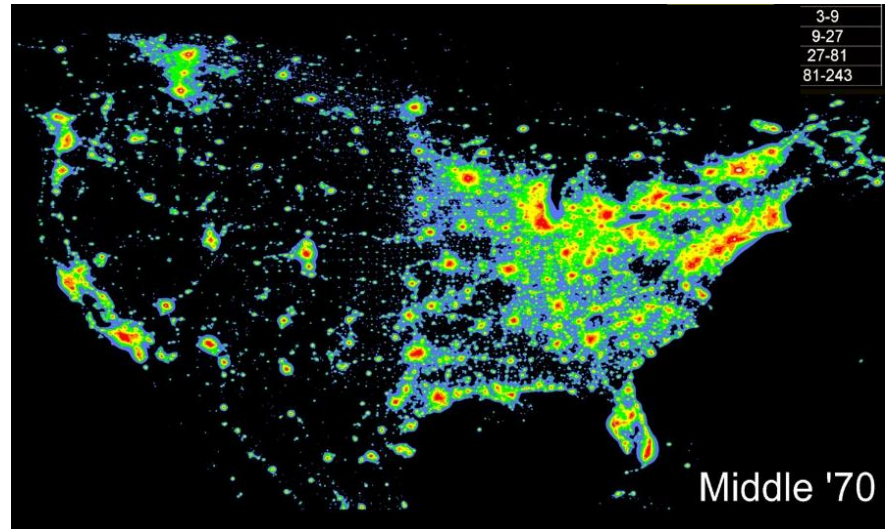
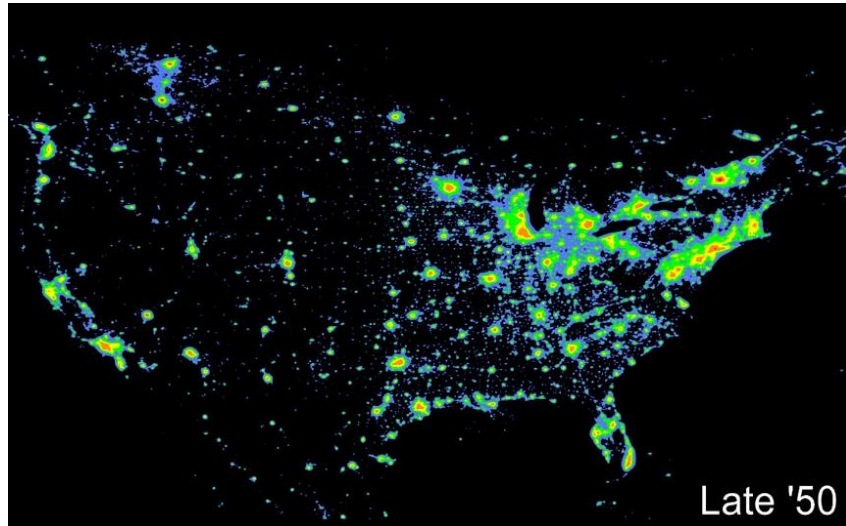


# What is Light Pollution?

- It is **wasted light** that performs no function or task
  - Sky glow
  - Glare
- It is artificial light that goes where it's not supposed to go
  - Neighbor's window (Light **Trespass/clutter**)
  - Into the sky
- **Light Pollution** is the introduction of artificial light, either directly or indirectly, into the natural environment.



# Light Pollution



# Light Pollution is a LOCAL problem with LOCAL solutions

Protecting the night sky starts with **YOU!**

- 1** Light only  
what you need



- 2** Use energy  
efficient  
bulbs and only  
as bright as  
you need



- 3** Shield lights and  
direct them down



- 4** Only use  
light when  
you need it



- 5** Choose  
warm white  
light bulbs



- 6** Join IDA!  
We need your help to continue  
the fight against light pollution.



# Motivation

- Light Pollution is a major **concern for Astronomers** (especially amateur astronomers, but also professional astronomers)
- **Interdisciplinary Research**
  - LED lights with different colors and effect on humans/animals/plants
  - Retrofitting 'bad' light fixtures, designing shielded light fixtures
  - Health/Environmental issues
- **LED lighting**
  - Potential increase in outdoor lighting, since LEDs will be 'cheaper'
  - Nullifies economic reasons to be more 'responsible' with outdoor lighting
  - Also nullifies environmental rationale against excessive/inefficient lighting
- Opportunity to engage astronomy/other students in '**Civic Engagement**' and outreach



# The Light Pollution Project

- **Research: Quantifying Light Pollution**
  - Light sensor measurements to quantify light pollution
  - DSLR Photography
  - DSLR Photometry
- **Actions: Fixing the Problem**
  - Remedies for 'bad' light fixtures
  - Communicate with administrators (school, city etc)
  - Funding Sources (currently Missouri Space Grant for basic research & outreach)
- **Education & Outreach**
  - 'Losing the Dark' Planetarium Show, IDA brochures
  - Intro Astronomy Lab on light pollution
  - Interdisciplinary research projects & Civic Engagement

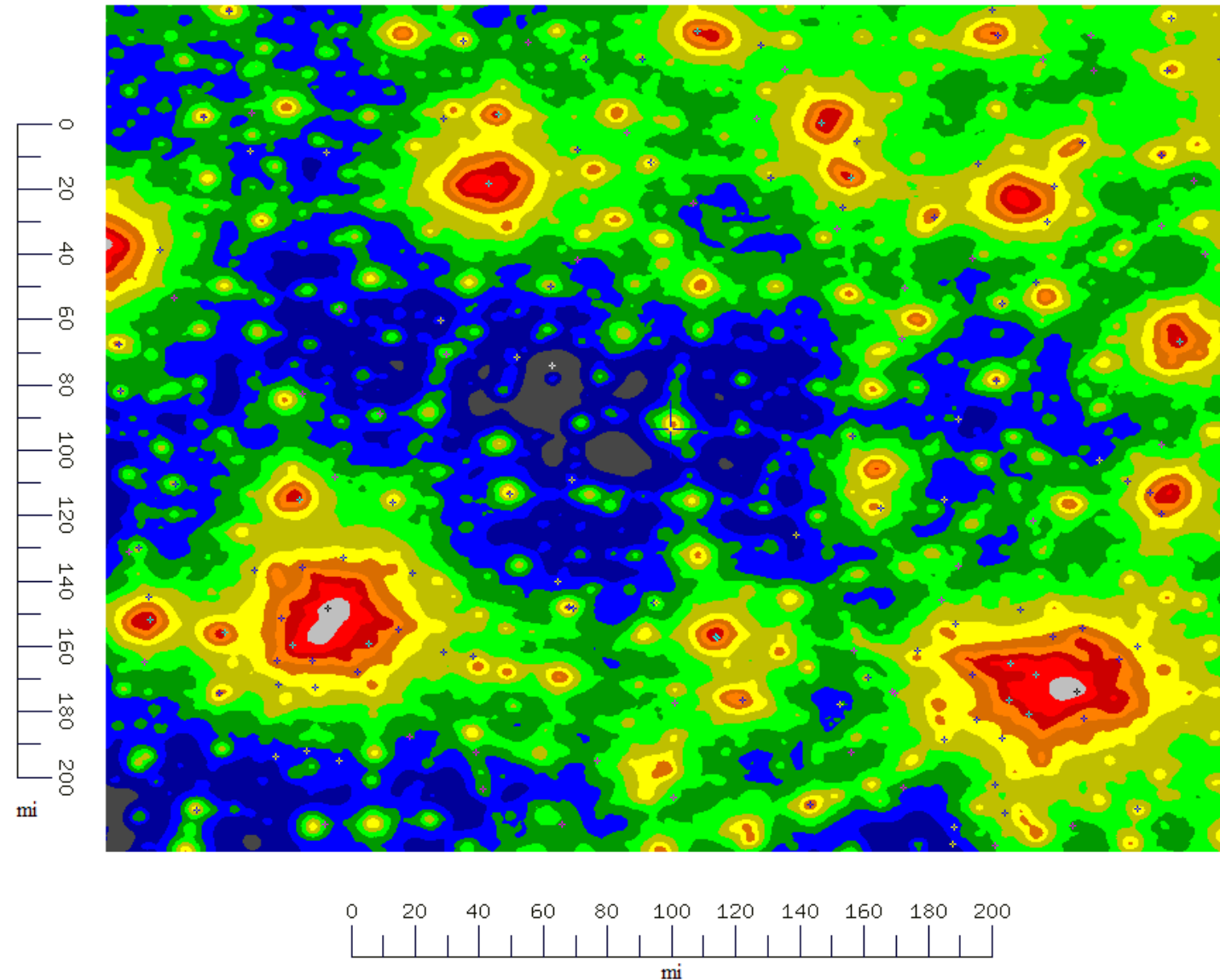
# Light Sensor: Set up



The entire set-up cost is less than \$400 (for ethernet-sensor)



# Light Pollution Map



Color	Artificial / Natural Sky Brightness	Sky Brightness mags / sq arcsec V Band	<a href="#">Bortle</a> <a href="#">Scale</a> approx
	< 0.01	22.00 to 21.99	1
	0.01 to 0.06	21.99 to 21.93	2
	0.06 to 0.11	21.93 to 21.89	2
	0.11 to 0.19	21.89 to 21.81	3
	0.19 to 0.33	21.81 to 21.69	3
	0.33 to 0.58	21.69 to 21.51	4
	0.58 to 1.00	21.51 to 21.25	4
	1.00 to 1.73	21.25 to 20.91	4.5
	1.73 to 3.00	20.91 to 20.49	4.5
	3.00 to 5.20	20.49 to 20.02	5
	5.20 to 9.00	20.02 to 19.50	5

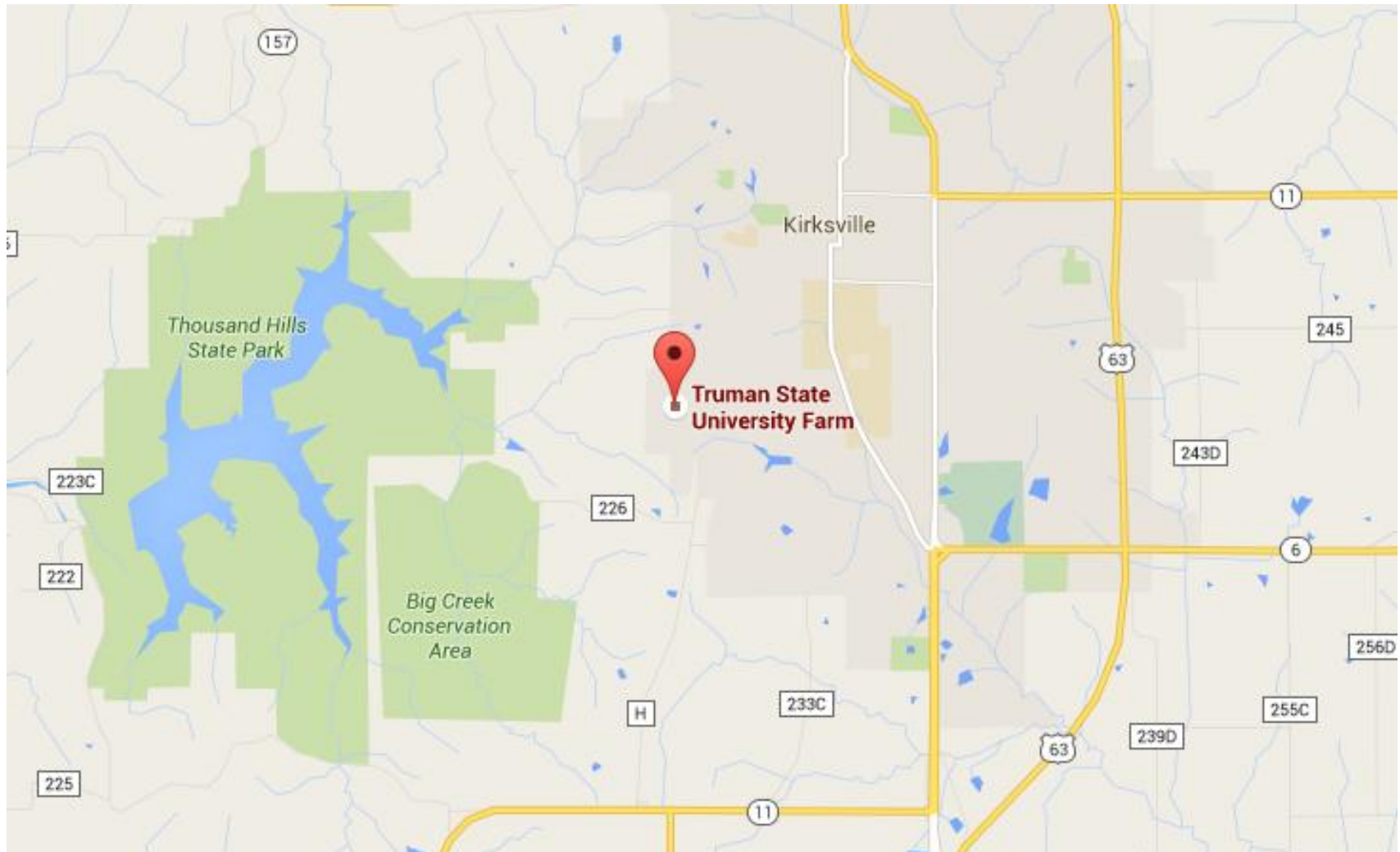


# Light Sensor Readings: Interpretation

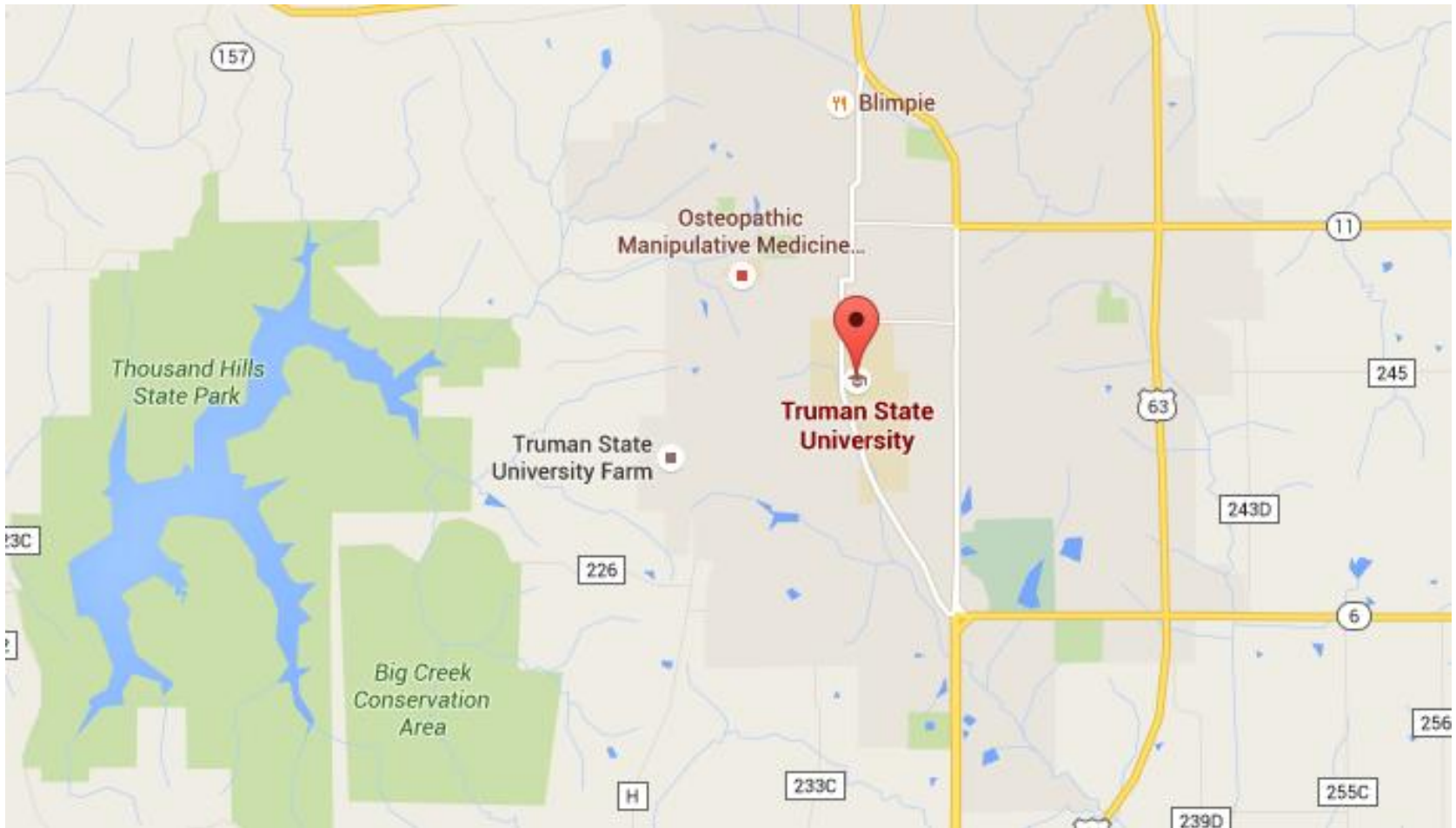


Numbers are in mags/arcsec<sup>2</sup>

# Location: Rural (City toward NE)



# Within City (Roof of Science building)



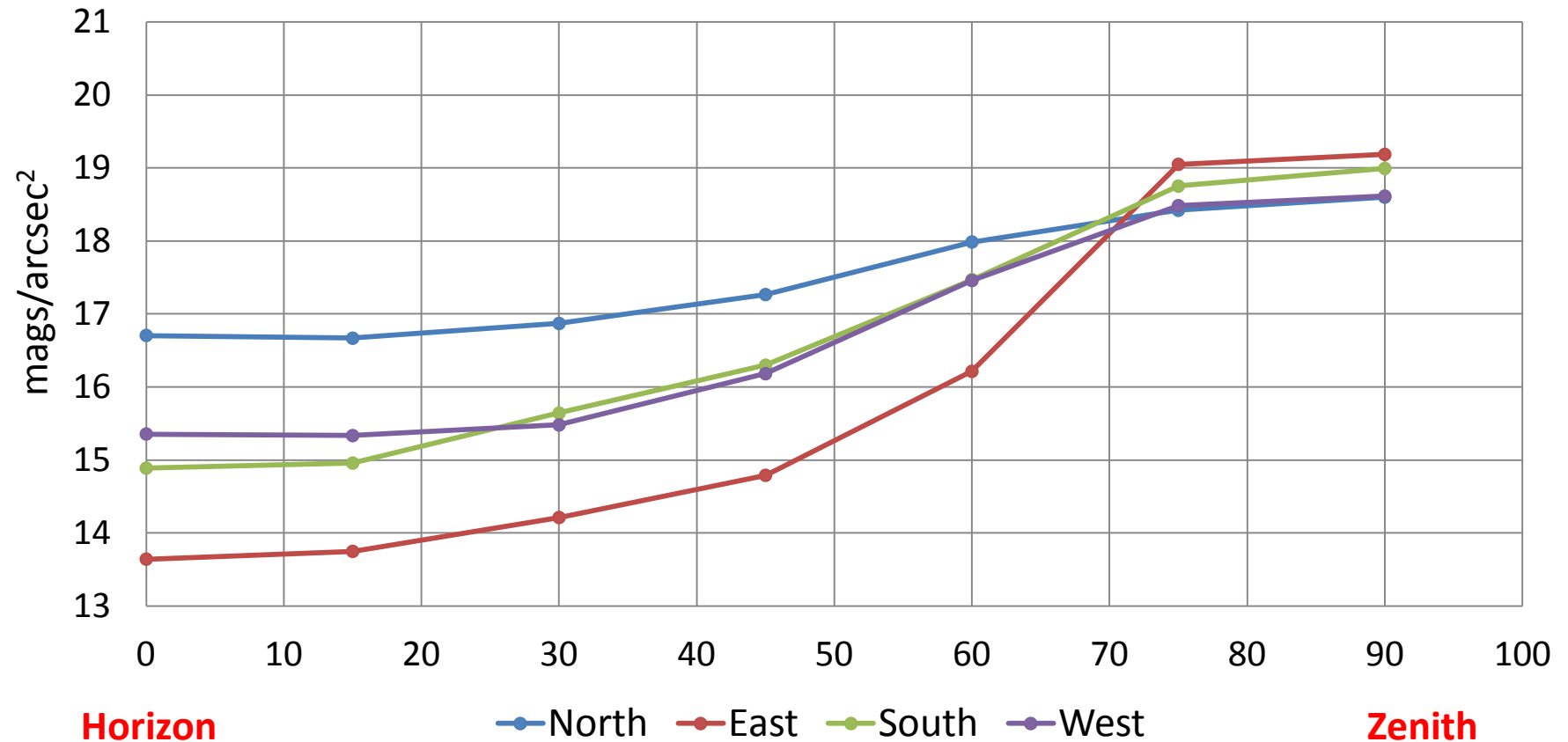


The graph displays the magnitude per arcsecond squared ( $\text{mags/arcsec}^2$ ) as a function of position angle for four different directions. The West direction consistently has the highest magnitude, while the East direction has the lowest. All directions converge to a similar magnitude of approximately 20.15 at a position angle of 90.00.

Position Angle	North	East	South	West
0.00	19.88	19.22	20.18	20.90
15.00	19.65	19.10	20.10	20.72
30.00	19.55	19.28	20.00	20.53
45.00	19.64	19.45	20.05	20.42
60.00	19.80	19.65	20.20	20.39
75.00	19.91	19.96	20.24	20.34
90.00	20.15	20.20	20.15	20.23

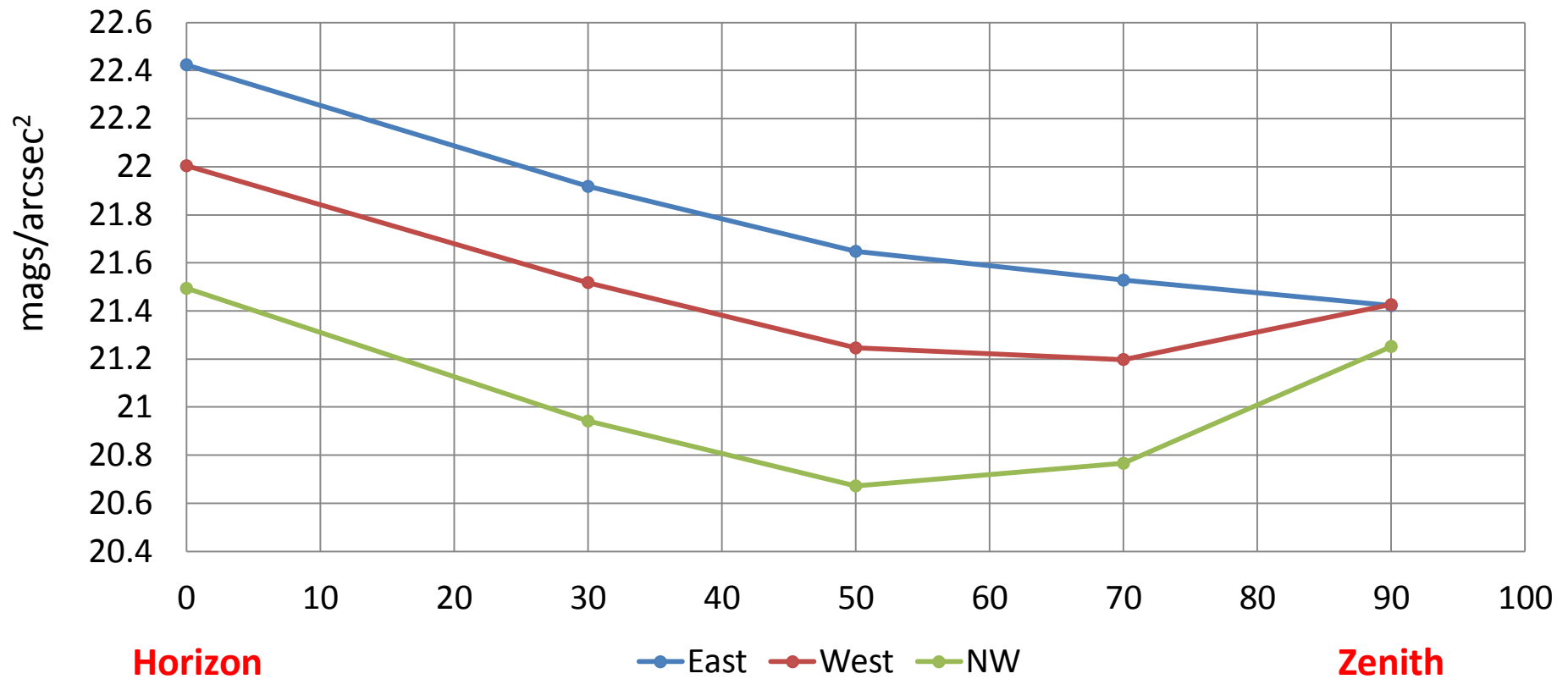
# Light Sensor Readings

04/02/2016 - Magruder Roof (City)



# Light Sensor Readings

03/10/2016 – Lowell, Observatory, Anderson Mesa  
(15 miles SE of Flagstaff)







Kraigstief, Mo

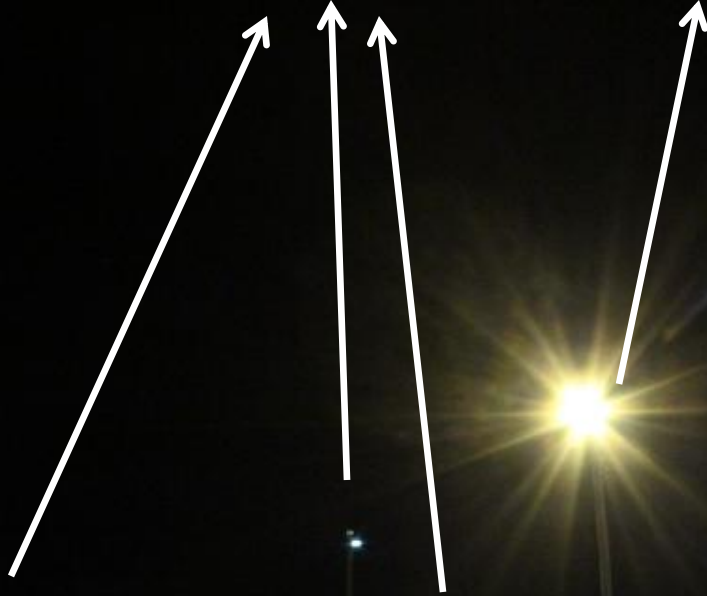
15minute exposure, tracking on



Kristine, Mo

130 minute exposure, tracking 'off'

# Good and Bad Lighting



Shaming the Admins  
Students: You pay for this!



Good

Bad



Notice the light going into the windows in the dorm rooms: Franklin Street

# Glare Bombs Galore: Franklin Street



# Glare Bombs Galore: Magruder/Violette Parking Lot





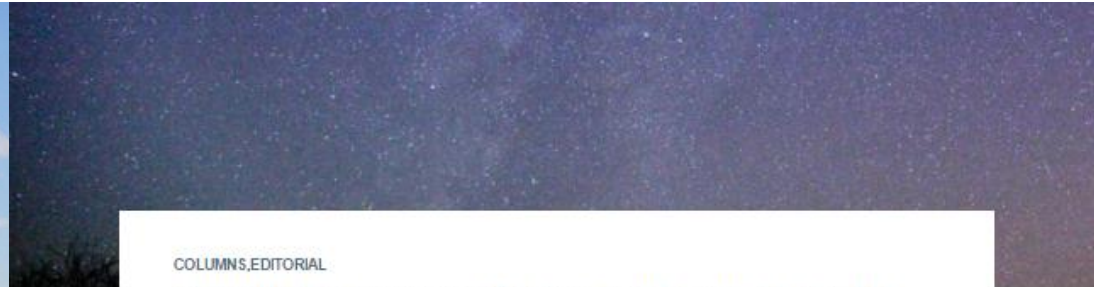
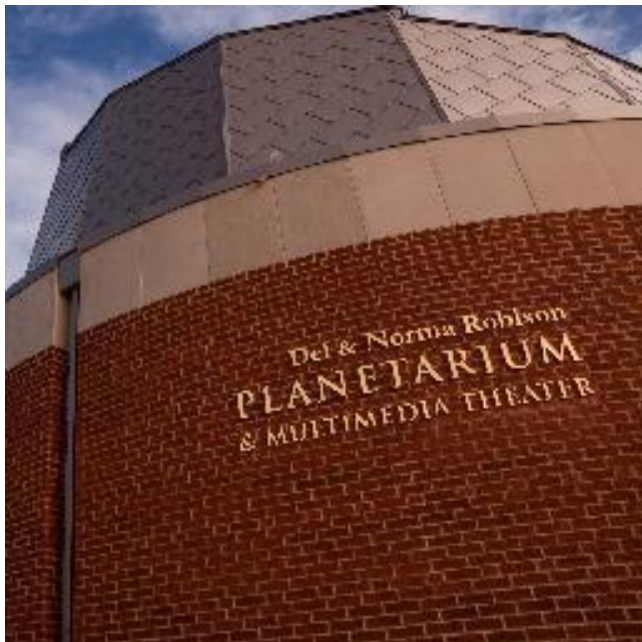
# Outreach/Awareness



LIFESTYLE, SCIENCE & TECHNOLOGY

## PROFESSOR INVESTIGATES LIGHT POLLUTION ON CAMPUS

© 26 FEB , 2016



COLUMNS, EDITORIAL

## OPINION: REDUCING LIGHT POLLUTION HAS MANY ADVANTAGES

© 8 NOV , 2015

By: Celine Fuchs



Guest Columnist Celine Fuchs discusses the detrimental effects of light pollution.

Take a nighttime stroll through campus. What do you see? Probably quite a bit — there's a lot of light. So take a step back and ponder for a moment what you do not see. Quite a few things, as it would turn out. I'm here to tell you what those things are.

Let's start by talking about how wasted light drains our wallets. You might have noticed during your stroll how the light from the globes on campus escapes everywhere, including upward. This throws light into the sky, wasting energy and money. However, if you look at the lights positioned in surrounding parking lots, such as the ones on the west side of Franklin and Patterson streets, they do a much better job of simply shining downward. Here, light isn't escaping through a clear top — it's being reflected back and



# What can I do?

Galloway Forest Park, Scotland | Ja



- As astronomers, we have to act to stem the growing nuisance of light pollution.
  - Politely talk to your neighbors, friends and relatives about glare bombs and unnecessary lighting, and the advantages of investing in shielded, smart lighting.
  - Raise this issue with administrators, city and municipal officials, local businesses.
  - Talk about Light pollution at planetarium shows ('Losing the Dark'), and Observatory open houses.
  - Urge your graduate and undergraduate students to bring up and pursue this issue through student environmental groups and student senate.

# References & Sources

gokhale@truman.edu



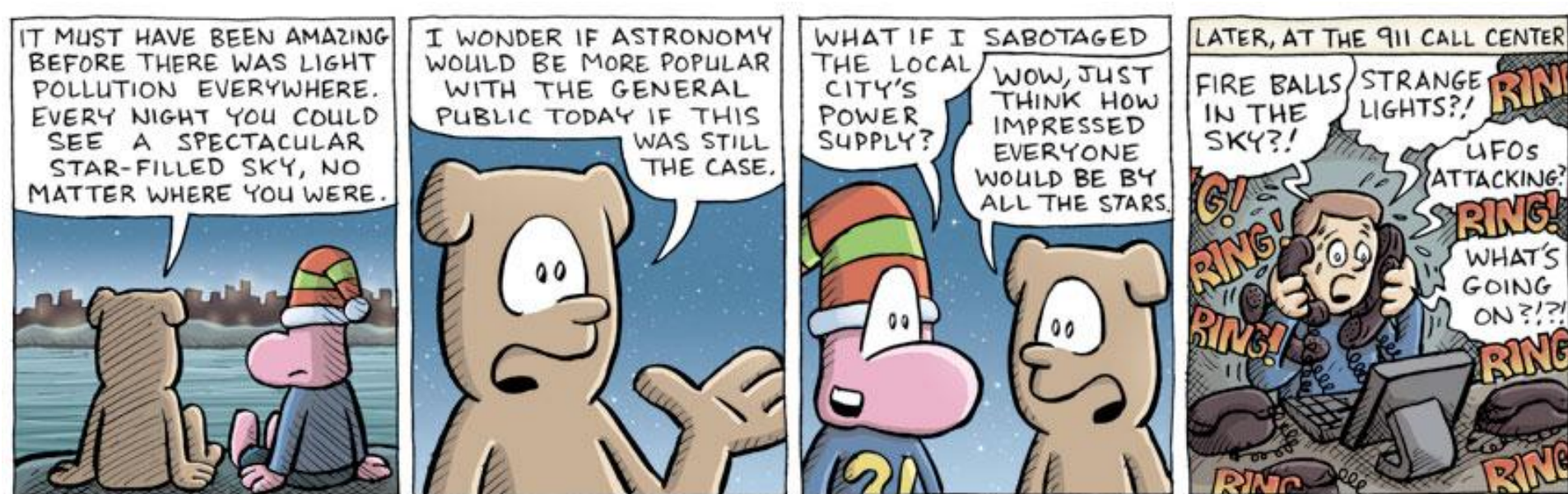
- IDA website: <http://www.darksky.org/>
- Losing the dark sky movie: <http://www.darksky.org/night-sky-conservation/290>
- Light Sensor: <http://unihedron.com/projects/darksky/index.php>
- What happened to the Milky Way?  
<http://www.theatlantic.com/video/index/384755/the-night-sky/>
- Paul Bogard: 'The End of Night' (Book)  
<http://www.theatlantic.com/technology/archive/2013/07/let-there-be-night/278070/>
- Flagstaff Dark Skies: <http://www.flagstaffdarks skies.org/>
- National Parks Service:  
<http://www.nature.nps.gov/night/index.cfm>

# Where we are Today



- “When a massive power outage struck southern California in the 1990s, Los Angeles residents reportedly called 911 to express alarm about strange clouds hovering overhead; they were seeing the Milky Way for the first time!” – Fraknoi

<http://www.pbs.org/seeinginthedark/astronomy-topics/light-pollution.html>



## Extra Slides



# Back of Envelope \$\$ Estimate



- A single 100 W bulb costs about \$25 to run for 12 hours a day for 365 days a year (@\$0.12 per kW-hour).
- If approximately 30% of light on average is 'useless light', this amounts of about \$15 wasted per 100W light bulb.
- Assuming 10,000 light fixtures (homes, apt complexes, street lights, gas stations, parking lots, offices, University etc) that are 'on' all night; this amounts to \$150,000 wasted dollars per year.
- And there is additional wastage from excessive indoor lighting as well.
- Add to this the environmental impact, and secondary expenses related to health.

# Back of Envelope Carbon Footprint Estimate



- 1 KW-hour corresponds to 10,768 BTU.
- $4.4 \times 10^6$  KW-hour per year is consumed by ten-thousand 50 W bulbs burning 12 hours a day.
- This corresponds to  $4.74 \times 10^{10}$  BTUs, which in turn corresponds to 2370 tons of coal, or 8170 barrels of oil.
- If 30% of this is wasted as glare or sky-glow; this corresponds to about **700 tons of coal**, or **2500 barrels of oil per year**.

# What can I do?

Galloway Forest Park, Scotland | James Hilder

<http://www.darksky.org/assets/documents/PG3-residential-lighting.pdf>

2

PG 3: Residential Lighting



George Fleenor

The glare from an unshielded light creates deep shadows.



George Fleenor

The glare from the light hid a possible attacker.

**Don't hesitate to ask your**

## Practical Actions:

1. **Make friends, not enemies.** Your neighbors probably don't realize the light is bothersome.
  - Always approach people in a friendly, non-threatening way.
  - Don't argue. Be tactful and understanding about their right to light their property.
  - Don't dismiss their need to feel safe.
  - Suggest alternatives to their current fixture. Ask them to move the light, shield it or add a motion sensor.
2. **Be informative.** Talking to your neighbor is an exciting chance to be an advocate for good lighting and share knowledge on an important issue.
  - There are many reasons to use dark sky friendly lighting. IDA sound bites can help to convey the benefits:
    - » Dark sky friendly lighting does not mean dark ground.
    - » Safety is important, but brighter does not mean safer.
    - » A starry sky is a natural resource.
  - The topics of safety, energy savings, cost, wildlife are addressed briefly in this document. Additional articles and brochures from the IDA Web site are downloadable and free for use.
    - » Print off free materials from the IDA Education tab and present this information to your neighbor.

# Light Pollution Group At Truman



- **Inventory** of outdoor lighting
  - Street Lights
  - Parking Lots and Gas Stations
  - Truman & ATSU
  - Apt Complexes & Houses
- **Contact administrators** and city of Kirksville officials to accumulate data, assess the present **protocols** regarding outdoor lighting.
- **Contact the city police and Truman police** regarding the **safety** aspects of outdoor lighting.
- **Interface with other student groups** (student health, green-initiatives etc).
- Look for **funding opportunities** to assess, plan and implement improvements to outdoor lighting fixtures across the community.



# Consequences of Light Pollution

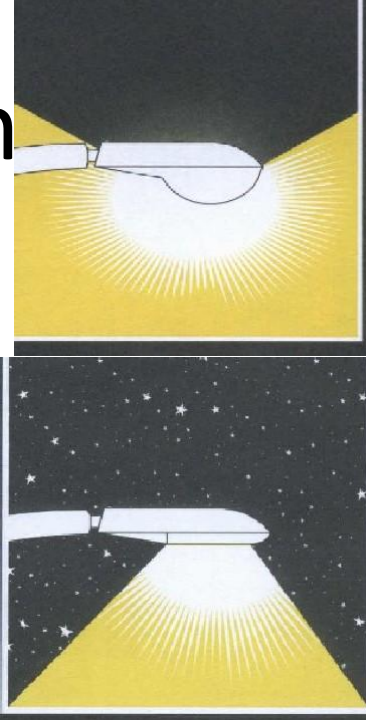
- Unshielded light sources

- Waste energy

- As much as 30% of outdoor lighting is beamed upward, toward the sky, rather than toward the ground.

- Are unsafe (very counterintuitive)

- Glare from misdirected bright lights can blind you.
    - The human eye is a remarkable instrument capable of seeing very faint objects.
    - However, if the brightness ratio between two objects is greater than 20:1; the eye cannot discern objects around the glaring light, rendering us vulnerable to an ambush.



# Non-shielded lights are unsafe

- The glaring lamp to the right of the path was installed to protect.



# Where did the student go?



IDA in Partnership with NOAO, NSF and IYA  
Dark Skies Awareness



# Examples of Bad Lighting



George Fleenor

The glare creates deep shadows.



George Fleenor

The glare from the light hid a possible attacker.



# Examples of Bad Lighting



Martin Morgan-Taylor

Overly bright light can mask intruders.



Martin Morgan-Taylor

With the light shielded, the intruder is easily seen.

# Light Pollution

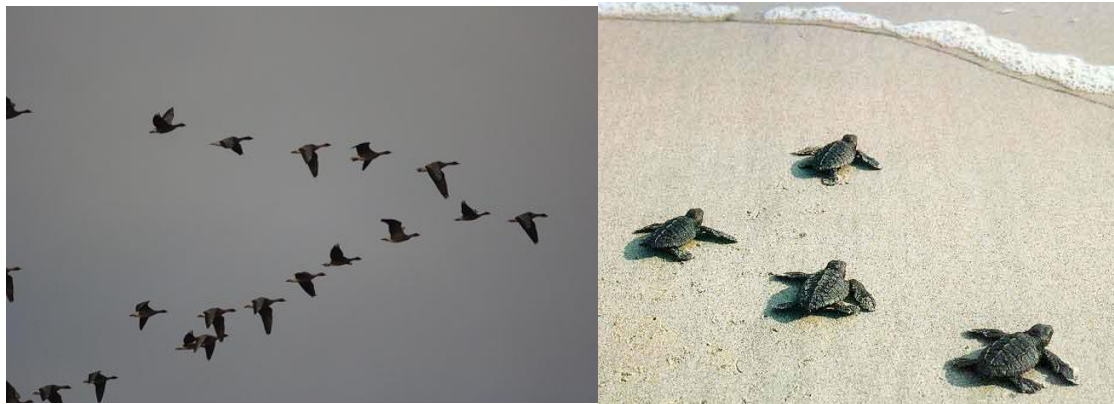


- Unshielded light sources
  - Negatively impact animals, including humans.
    - Disturbs *Circadian* rhythm, resulting in insomnia, depression, cancer and cardiovascular disease.
    - The ‘blue’ portion of light is especially harmful since exposure to it affects release of the hormone *Melatonin*.
    - In 2009, the AMA adopted resolutions that support reduction of light pollution and glare; and advocate for energy efficient, fully shielded outdoor lighting.

# Light Pollution



- Unshielded light sources
  - **Negatively impact animals, including humans.**
    - 100 million birds a year throughout North America die in collisions with lighted buildings and towers.
    - Artificial lights can also cause migrating birds to wander off course and never reach their natural destination.



# Light Pollution



- Unshielded light sources
  - Negatively impact astronomy
  - In astronomy, the role of ‘experimentation’ is largely taken by ‘observations’.
  - These observations are based on light (gamma rays, x-rays, uv, visible, IR, Radio etc) emitted by objects at immense distances from Earth.



# Light Pollution



- Unshielded light sources
  - **Negatively impact astronomy**
    - It is on the basis of studying the properties of this light that astronomers are able to piece together what the properties of the emitting object are.
    - Sky glow interferes with astronomers' ability to look the quality and quantity of light coming from these objects.
    - Sky glow decreases the ability to see fainter stars, meteor showers and nebulae; and thus affects stargazing and amateur astronomy.

# Unnecessary Indoor Light

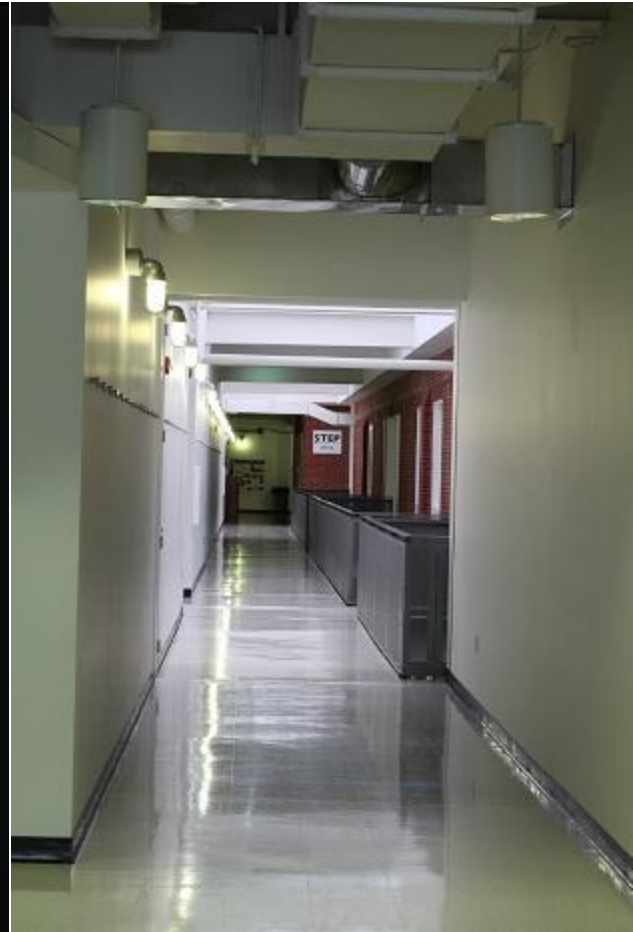


Tube-lights illuminating ceiling tucked above vents in Magruder

# The luminous beauty of the wires and pipes in Magruder



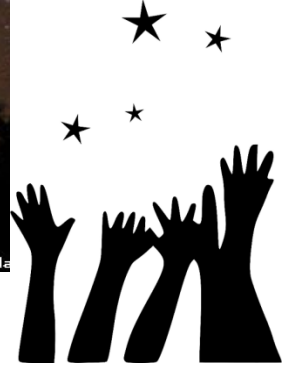
Blazing away to glory in broad daylight





# What can I do?

Galloway Forest Park, Scotland



- Pima County, which includes Tucson, has the following 'light ordinance' in effect:

*The purpose of this code is to preserve the relationship of the residents of the City of Tucson, Arizona and Pima County, Arizona to their unique desert environment through **protection of access to the dark night sky**. Intended outcomes include **continuing support of astronomical activity and minimizing wasted energy**, while **not compromising the safety, security, and well being of persons engaged in outdoor night time activities**. It is the intent of this code to control the **obtrusive aspects of excessive and careless outdoor lighting** usage while preserving, protecting, and enhancing the lawful nighttime use and enjoyment of any and all property. It is recognized that developed portions of properties may be required to be unlit, covered, or have reduced lighting levels in order to allow enough lumens in the lighted areas to achieve light levels in accordance with nationally recognized recommended practices.*