



 **CFM** **89<sup>th</sup> Annual**  
**Convention**  
February 25-27 & March 3-5 - Virtual  
March 7-9, 2025 - Lodge of Four Seasons, Lake Ozark, MO

# Dark Sky as a Natural Resource

Vayujeet Gokhale

Professor of Physics and Astronomy  
Truman State University

1. Perspective

2. Defining the Problem

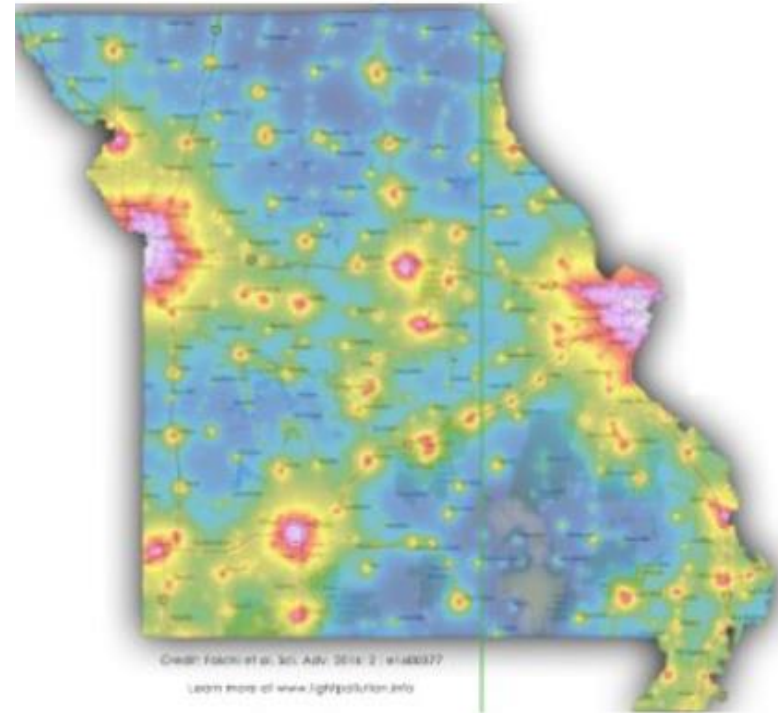
3. Solutions (*Handout*)

4. DarkSky Missouri (*Handout*)

a) Educational Initiatives

b) CFM supported Projects

c) "DarkSky kit" (*Handout*)



5. What can you do?

# Perspective

*“...shadows from the starlight,  
softer than a lullaby...”*

# Blue Skies, Twilight, and Darkness at Night



# Blue Skies, **Twilight**, and Darkness at Night



“Darkness” at night



Flagstaff, Az

5 minute exposure, tracking 'on'

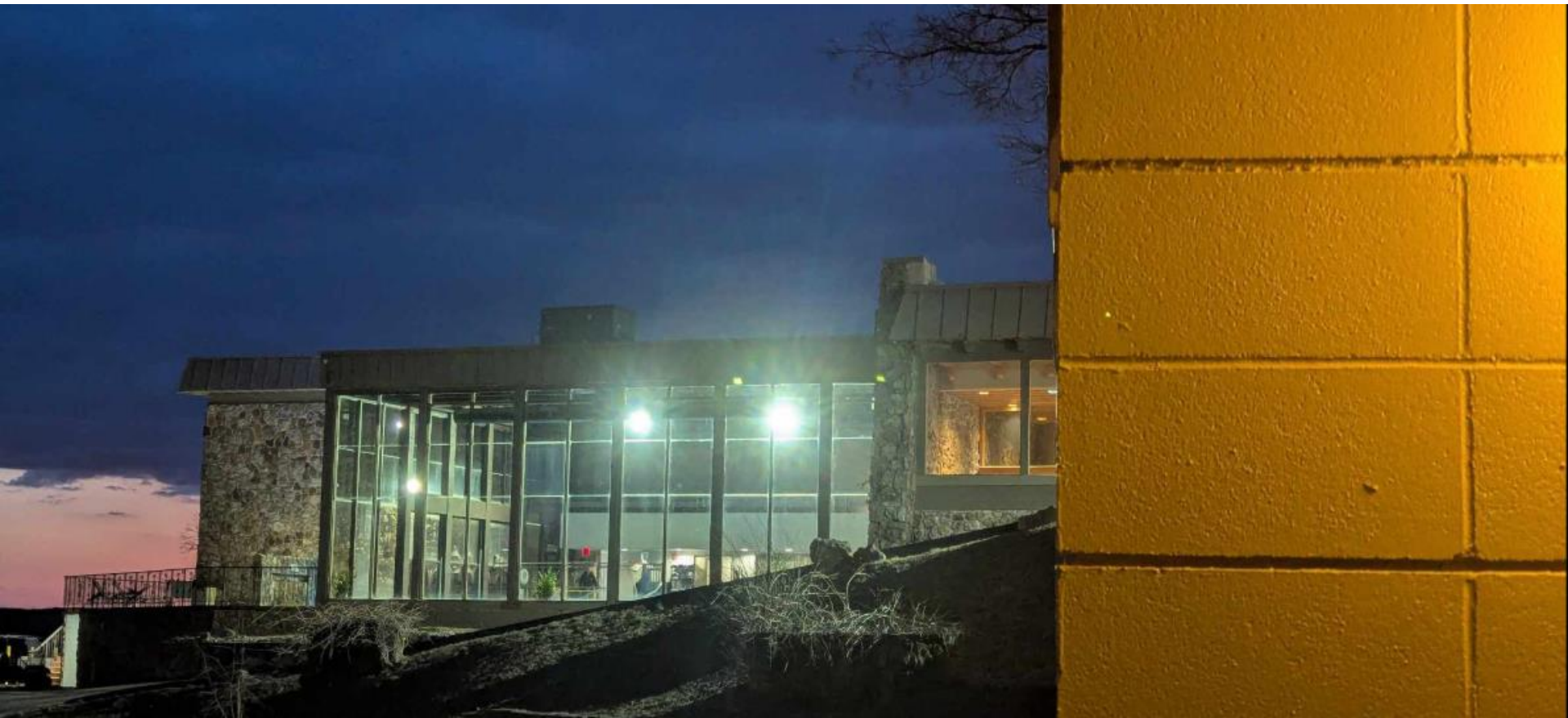
Dark Sky advocate goes to a tourist town like the Lake of the Ozarks.

What does he do right away!?



CCT = 1900 K

Dark Sky, human, and wildlife friendly  
amber colored lights!!



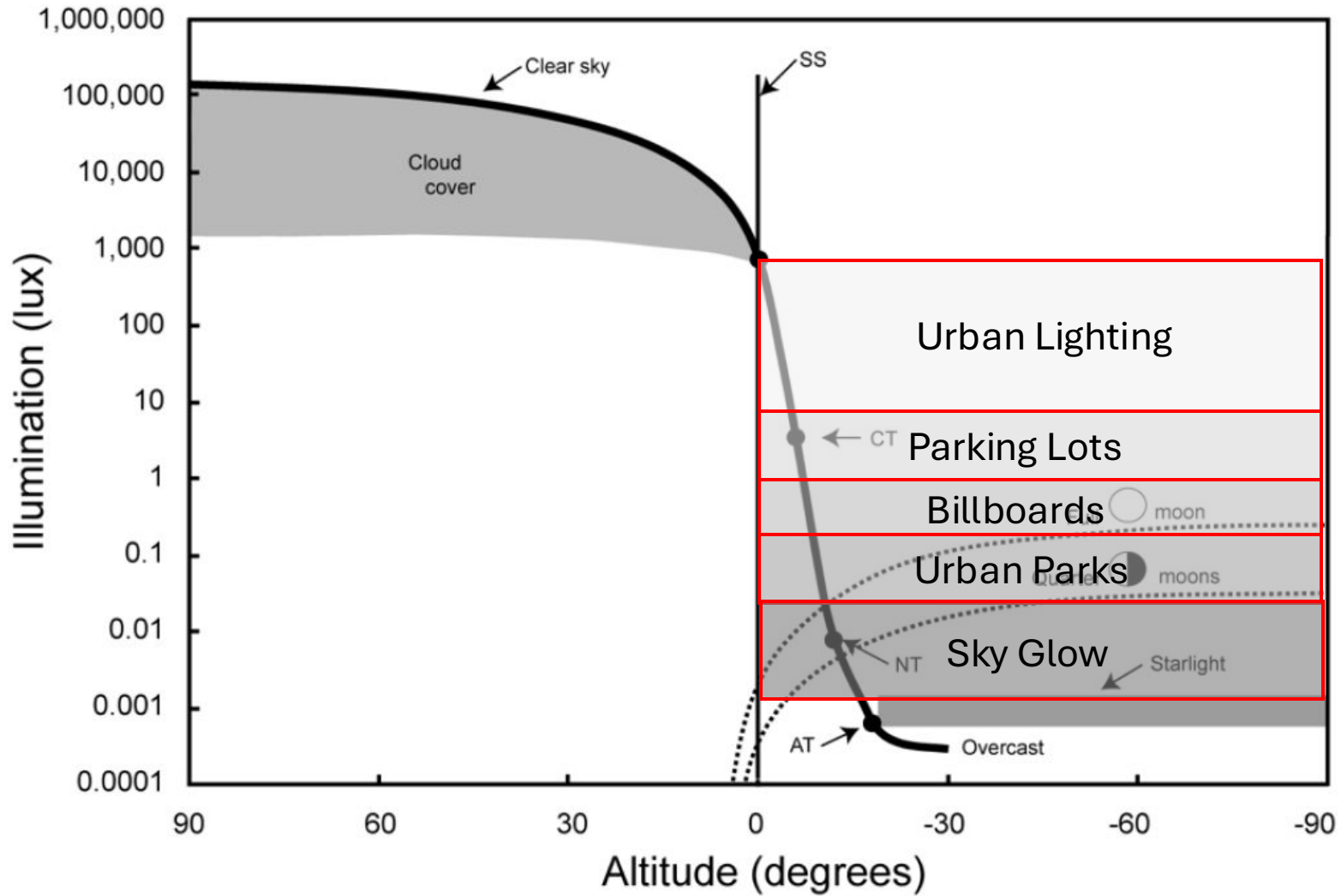
But... still work to be done.  
CCT = 4,500 K

# Defining the Problem

*" Look at the stars,  
look how they shine for you..."*

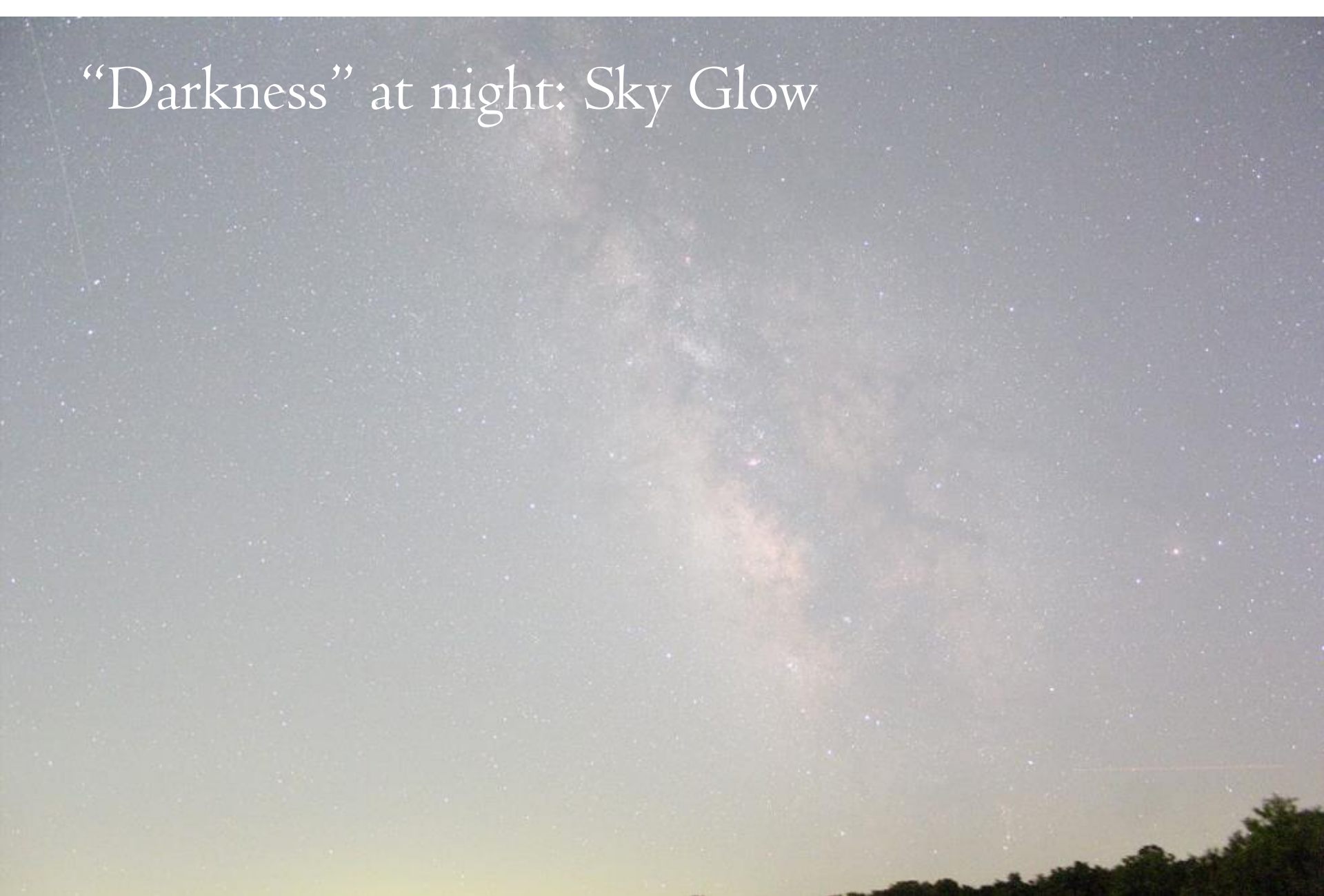


# Natural Illumination Night and Day



Credit: T. Longcore

# “Darkness” at night: Sky Glow



Kirksville, Mo

1 minute exposure, tracking 'on'

# What is Light Pollution?

[ALAN = Artificial Light At Night]

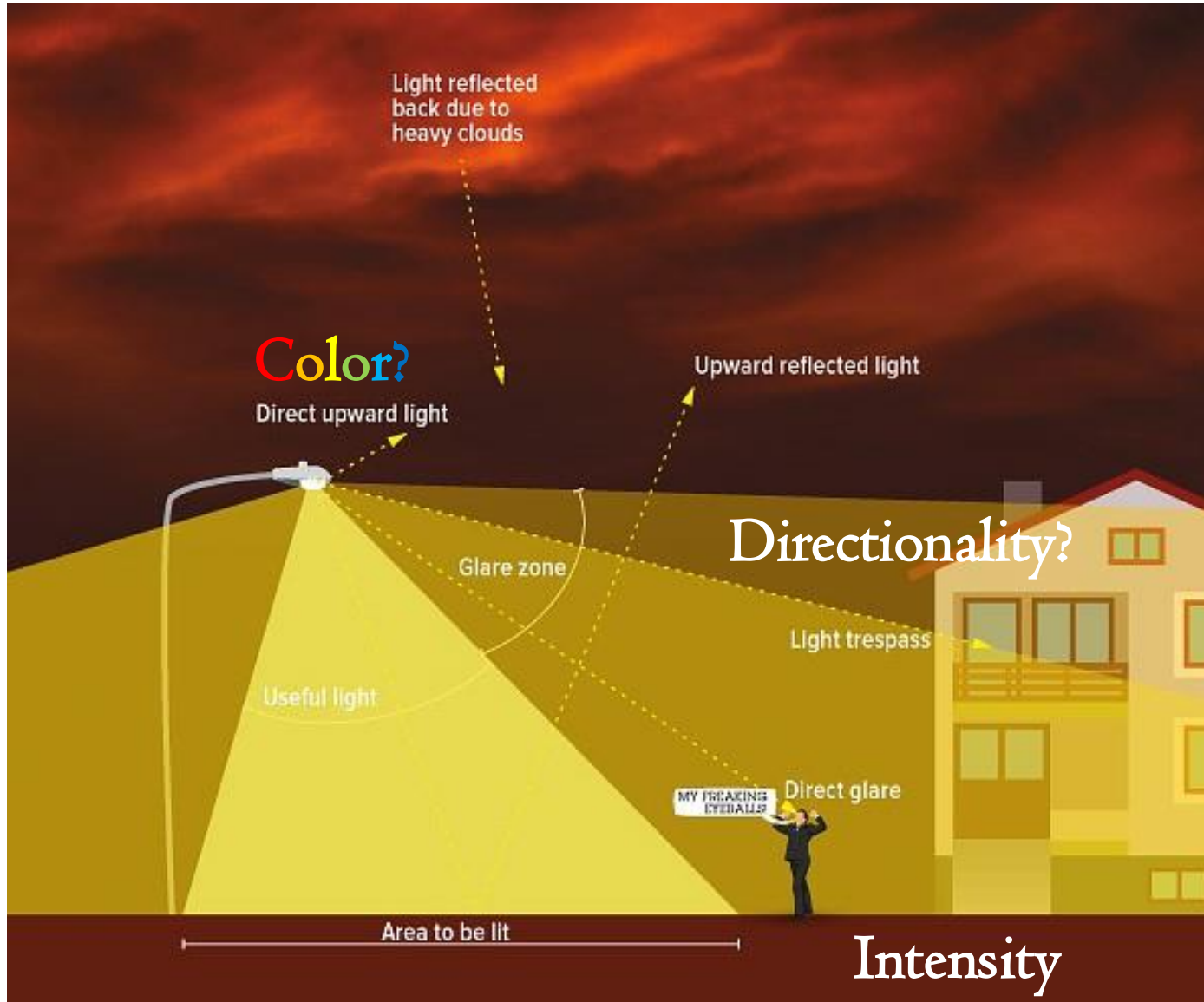


Photo Credit: Dark Sky International

# Amber, Blue, and White Light



Walmart @Flagstaff, Az



Residential Neighborhood  
Albuquerque, NM

Parking lot  
@ Truman State



# Responsible Lighting at Night

*"Let there be night..."*

# Reducing Light Pollution



Shielding

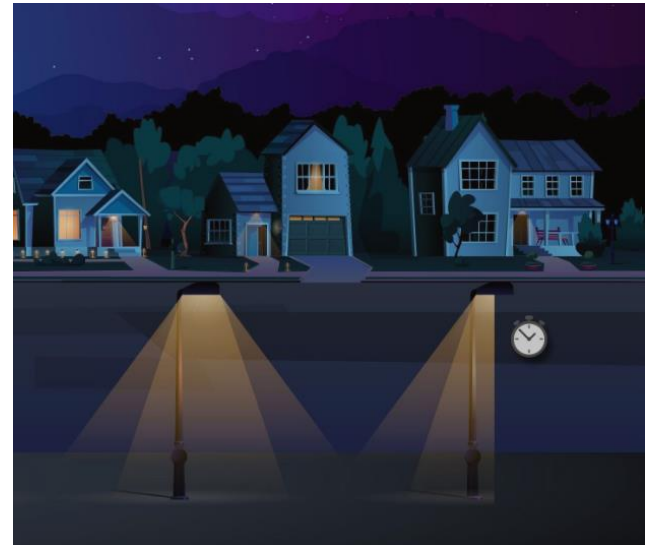


Color



Intensity

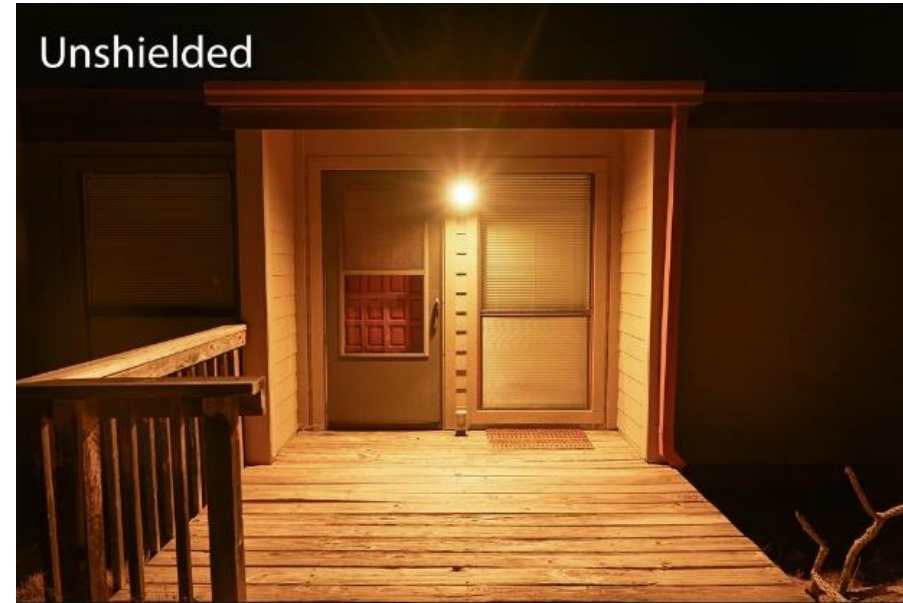
<https://www.bigbenddarkskyreserve.org/lighting>



Purpose & Timing

# Examples: Residential

Unshielded



Shielded



Las Cruces, NM

Near Big Bend NP, Texas



Printco@Alpine, Tx



Walmart @Flagstaff, Az



Oil Tanks@  
Balmorhea, Tx

## SEE HANDOUT

### Five Lighting Principles for Responsible Outdoor Lighting



Responsible outdoor lighting is

#### 1 Useful

##### Use light only if it is needed

All light should have a clear purpose. Consider how the use of light will impact the area, including wildlife and their habitats.



#### 2 Targeted

##### Direct light so it falls only where it is needed

Use shielding and careful aiming to target the direction of the light beam so that it points downward and does not spill beyond where it is needed.



#### 3 Low Level

##### Light should be no brighter than necessary

Use the lowest light level required. Be mindful of surface conditions, as some surfaces may reflect more light into the night sky than intended.



#### 4 Controlled

##### Use light only when it is needed

Use controls such as timers or motion detectors to ensure that light is available when it is needed, dimmed when possible, and turned off when not needed.



#### 5 Warm-colored

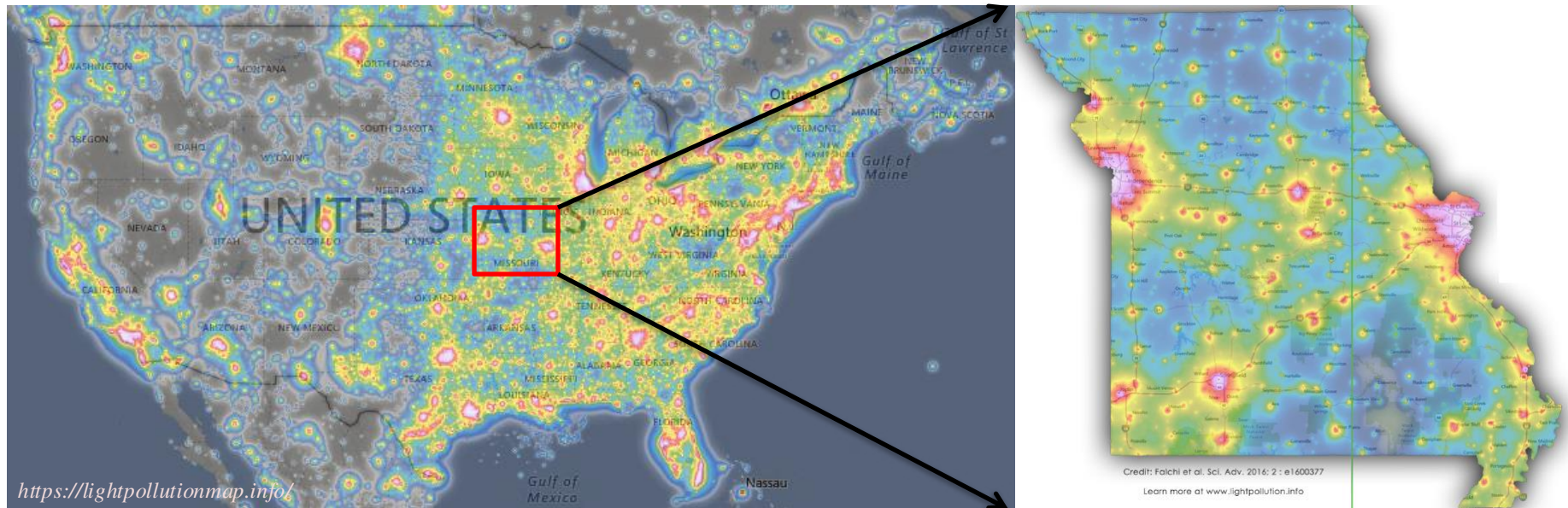
##### Use warmer color lights where possible

Limit the amount of shorter wavelength (blue-violet) light to the least amount needed.



- The technical **solutions to light pollution are rather straight-forward**: minimize use of outdoor light, direct it where it is needed, and use amber/red light instead of blue-white light.
- The bigger challenge is to overcome **individual and institutional inertia** and make people change their habits.

# The Challenge



“The loss of the night sky is placed in the broader context of society’s difficulty in fully articulating non-consumptive values such as natural beauty.”

How to bridge  
this gap!?

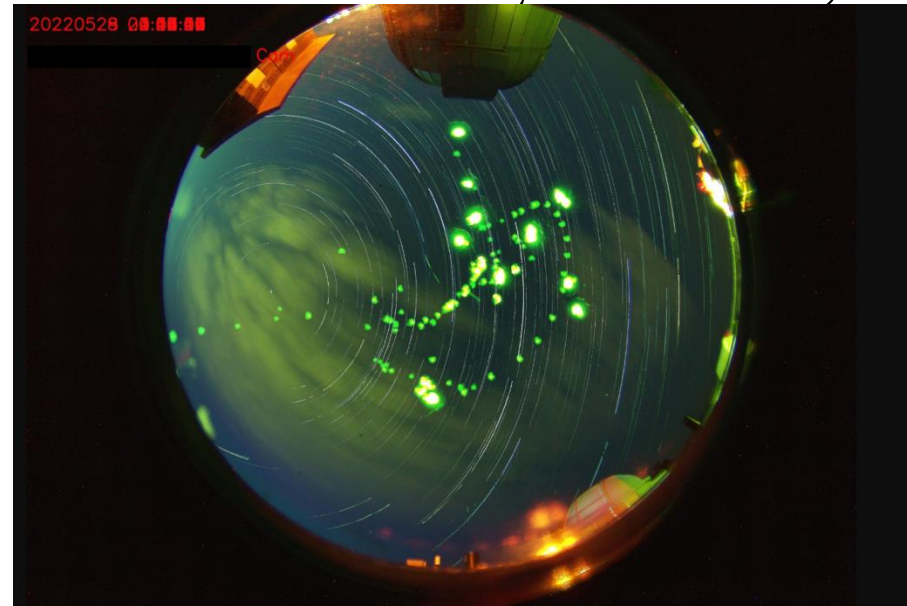
Terrell Gallaway  
(Missouri State University; IDA-Mo Board Member)

# Why protect Dark Skies?



# The Dark Sky is a Natural Resource

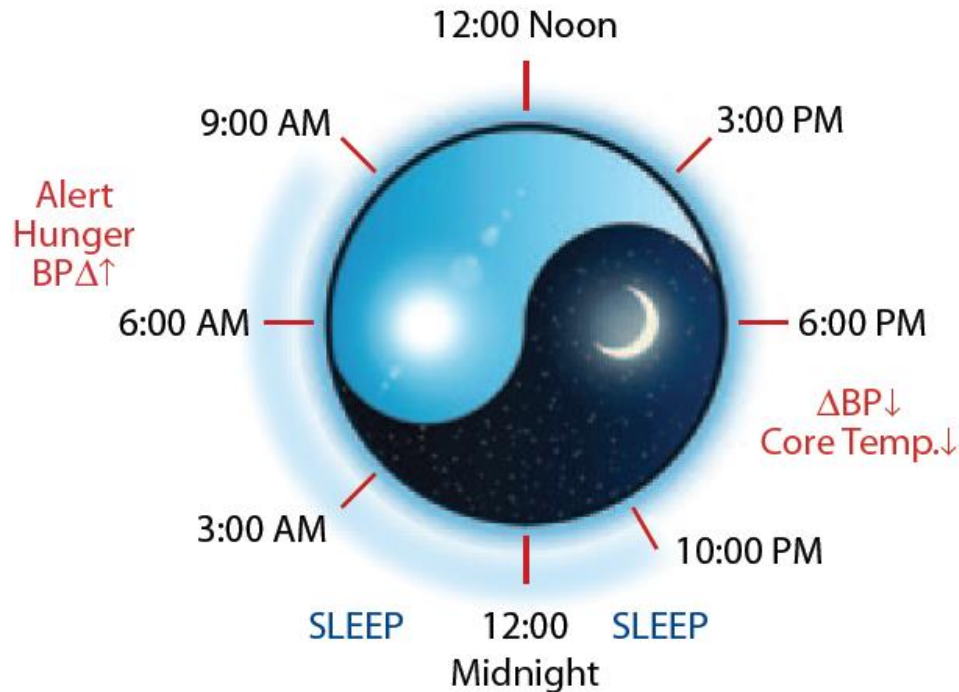
1. Dark Sky Heritage: Stargazing, myths, constellations, loss of night, light pollution
2. Darkness and Human wellbeing
  - a) Circadian Rhythm (Color of light bulb)
  - b) Direct glare (Intensity of light and directionality of fixture)
3. Impact on living beings
  - a) Birds and bird migration
  - b) Insects and pollinators
4. Savings
  - a) Improve health of ecosystems
  - b) Conserve precious natural resources



*Fireflies photobomb the  
all-sky-camera at the  
Truman State Observatory*

# Human Health

## Natural Dark / Light Cycle



*Figure 3 — The circadian dark/light cycle controls hormonal change, which modifies the sleep/wake cycle, blood pressure, sleep, and other physiological functions.*

<https://www.youtube.com/watch?v=BKQH6TIDZvI>



# ALAN and Humans

- **Glare** affects most of us, most commonly in the context of vehicle head-lights and/or bright LEDs mounted sideways on walls and/or Electronic Billboards
- LED lights, due to greater directionality, cause greater glare.
- Harder to quantify the effects of glare in terms of **color**, and its effects on “recovery time” of eyes.
- Severity of glare is related largely to the **dosage** (how bright?).



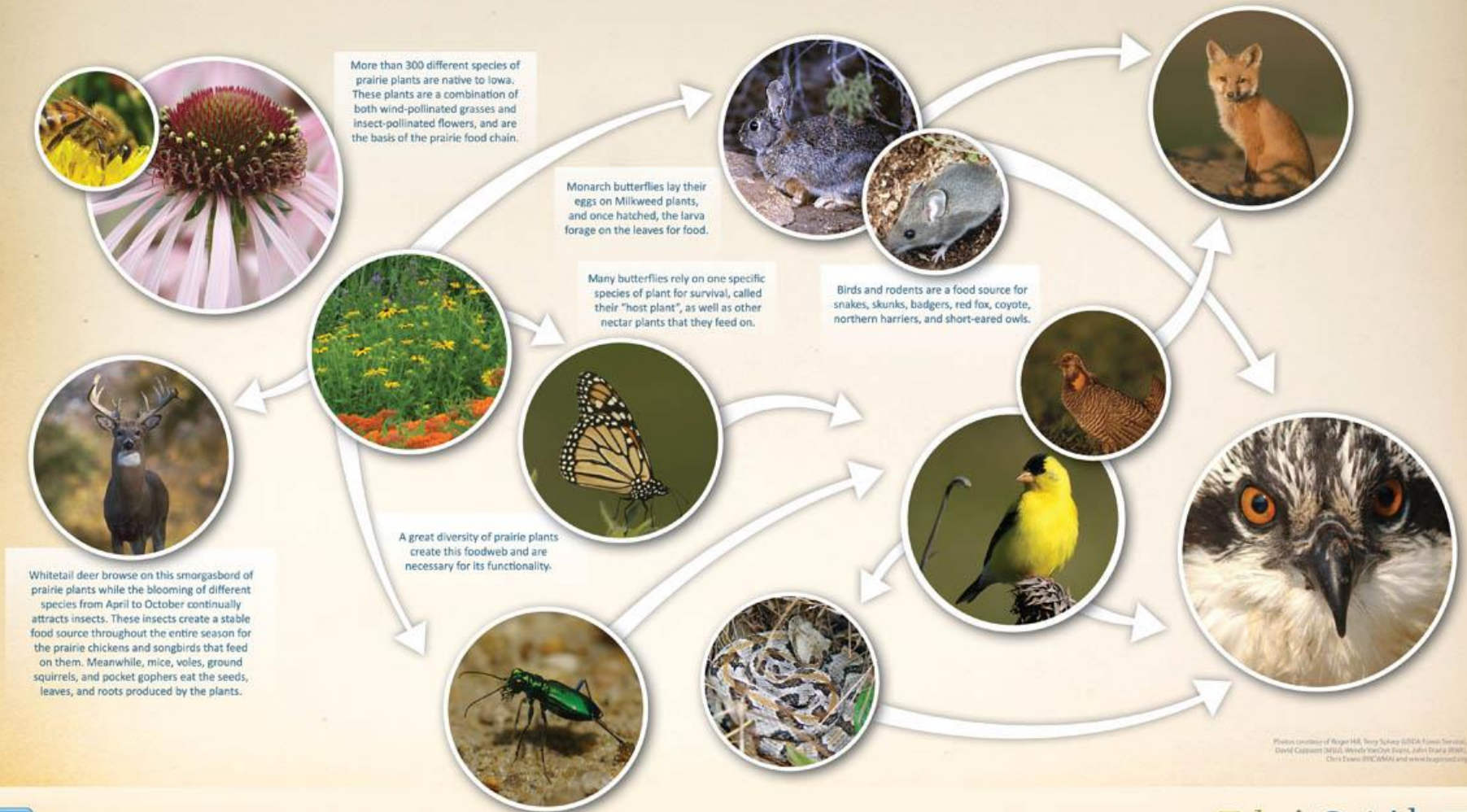
# Glare and Safety



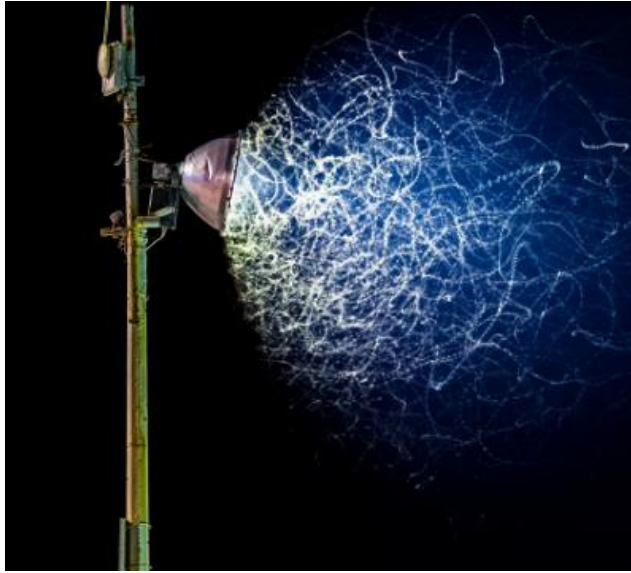
# Prairie Food Web

## Prairie Food Web

Prairie is attractive to many wildlife species as a food source, and its complexity helps ensure their survival.



Photos courtesy of Roger Hill, Terry Sweeney (IOWA Forest Service), David Casperson (IOWA Wetland/On Program, John Drake (IOWA), Chris Evans (IOWA) and www.iowadnr.org



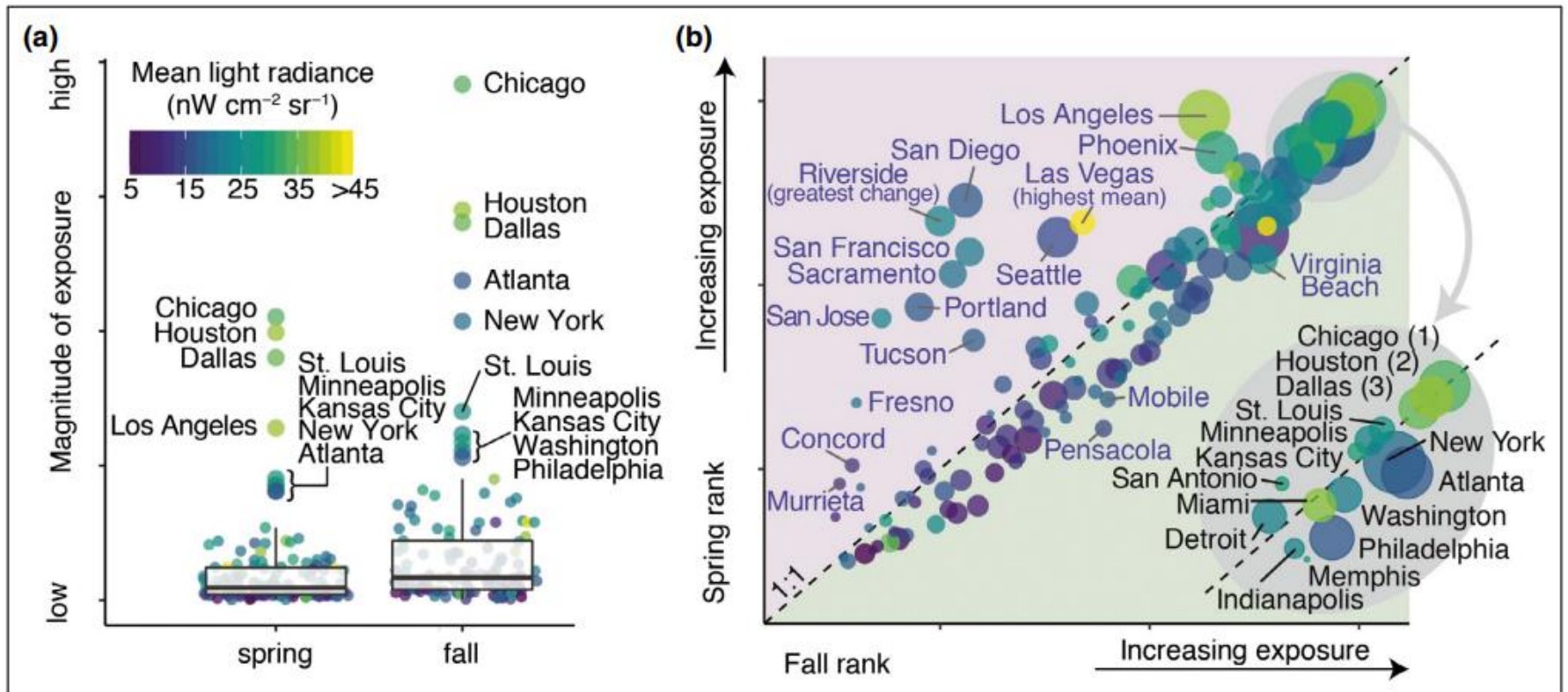
- Moths, including sphinx or hawk moths, are especially common and diverse nocturnal pollinators.
- Nocturnal pollinators use natural light from the stars and moon in the night sky to navigate.
- This light-seeking behavior draws them to artificial light where they become confused and trapped.

- Artificial light leaves pollinators exposed, making them easier to spot and reducing their ability to see these predators.
- Turn off unneeded lights whenever possible and shade windows during the twilight hours.

<https://www.pollinator.org/>



# ALAN And Bird Migration (Horton et al., 2019)



Seasonal (a) magnitude and (b) relative rankings of the 125 largest urban areas in the continental US. Point color shaded by the mean light radiance and sizes (in [b]) are scaled by the square root of urban area.

Inset in (b) depicts the top 15 (spring or fall) rankings

## **!! ATTEND SARAH KENDRICK'S TALK !!**

Saturday, March 8 - 2:15-3:15 p.m.

### TOPIC

**Back Yard Birding/  
Bird Conservation**

Sarah Kendrick

### DESCRIPTION

Join Sarah Kendrick, USFWS Migratory Bird Biologist, to learn how to start birdwatching – you may just get hooked! Learn about clues, tips, and tricks to learn more about the birds around you, in addition to how you can help birds in your daily life – and boy, do they need our help! Sarah will outline easy, scalable ways that you can help birds and the ecosystems around you that really make a difference. Birds need our help now! Join us to learn how.





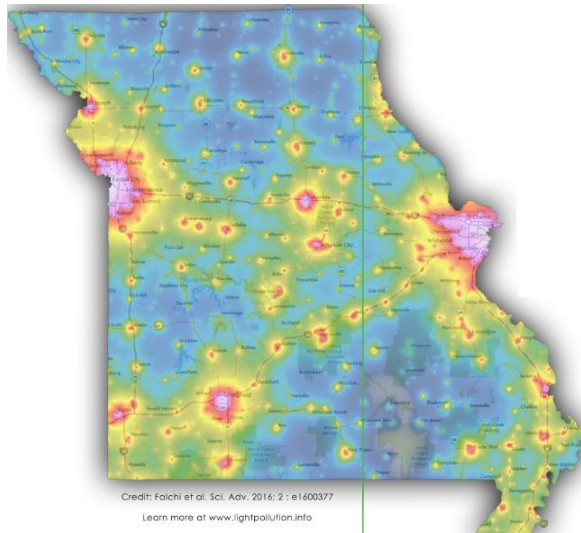
# DarkSky Missouri

*" Between the Swan and Hercules,  
Where even dark clouds glow..."*



## See Handout

The mission of DarkSky Missouri is to raise awareness about light pollution issues in Missouri, promote quality outdoor lighting, protect our natural environment and our beautiful night sky, and educate the public how reducing light pollution can lower energy costs.





# 2024 Select Achievements



1. First DarkSky Festival in Big Spring, Missouri (October 25-26, 2024)
2. **Thousand Hills State Park** near Kirksville, Missouri becomes second park (after Stacey Park in Olivette) to obtain Urban night Sky Status.
3. The city of Kirkwood passed an ordinance that lighting on all commercial buildings cannot exceed 2700K.
4. Successful **grant applications** to MOBCI, CFM, and MPF to pursue our educational and outreach goals.



# DarkSky Missouri: Goals



## I. Increase engagement with city, county, and state officials:

- a) Best practices
- b) Laws and ordinances
- c) Public and Private other wilderness areas  
(DarkSky certification, DarkSky Activities)

## 2. Educational and Training Programs targeting:

- a) School and College campuses,
- b) State Parks and Conservation areas,
- c) Aligned organizations (Master Naturalists, “Bird-people”, CFM affiliates etc.)
- d) Other concerned citizens

# Grant Supported Educational Initiatives





# Missouri Park Foundation Grant



1. **Five** participating State Parks in Missouri
2. Develop **Inventory** of all outdoor lights,
3. **Sky Quality** measurements
4. Provide **user manuals** and **training** to park rangers,
5. Start developing **Light Management Plan** and,
6. Set long term plan to achieve **dark sky status**.



# Campus SHINE



1. SHINE = Safe and Healthy Illumination in the Nighttime Environment
2. Nation-wide program initiated January 2025
3. “Missouri SHINE”, initiated in Fall 2024, includes:
  - a) Truman State University
  - b) SEMO
  - c) Missouri State
  - d) Jefferson College
  - e) Johnson County CC
  - f) Mizzou



# Campus **SHINE** : GOALS



1. Develop an **inventory** of outdoor lights
2. Quantify “Sky Brightness”
3. **Curricular training and development**
4. **Create awareness** about harm caused by irresponsible use of outdoor lighting and the straightforward solutions and,
5. Develop a “**Light Management Plan**” for campus\*.



# "DarkSky Kit" (Handout)



## I. Sky Quality Meter

- Standard device used for measuring sky brightness in mag/arcsec<sup>2</sup>
- Relatively easy to use even by non-scientists
- Excellent customer service



## 2. Opplé Lightmaster

- Easy-to-use handheld spectrometer
- Readings within 5% of more expensive luxmeters and spectrometers



## 3. Digital Illuminance Light Meter

- Standard device used by electricians and Power company technicians
- Easy to use, inexpensive





# CFM David Risberg Grant



*“Educating youth to advocate for the conservation of nighttime darkness as a natural resource”*

Wohlwend Elementary and Oakville Middle schools,  
St. Louis, MO

1. Two acres of native prairie, 6000 square feet pollinator habitat, several hundred foot riparian corridor.
2. Prior and ongoing collaborations with MDC, Prairie Foundation, Shaw Nature Center, and so on.



# CFM David Risberg Grant

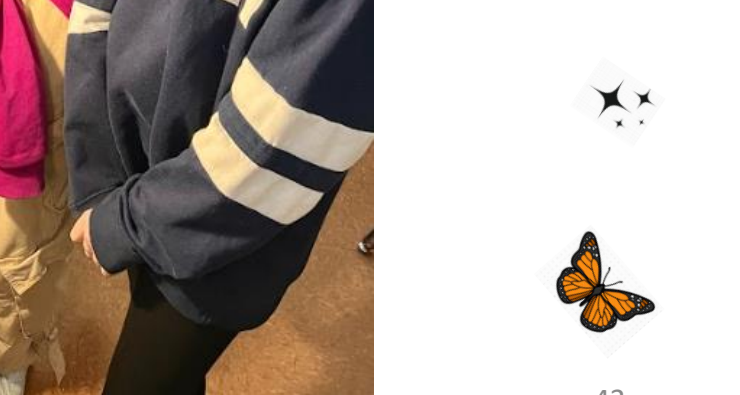
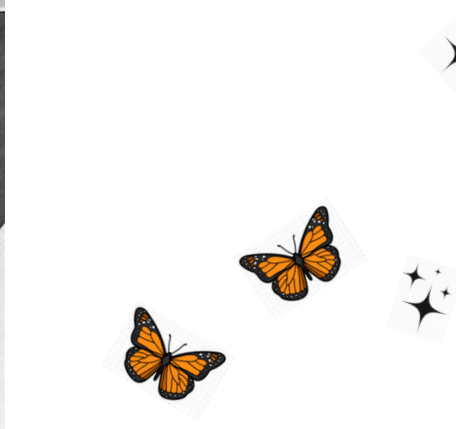
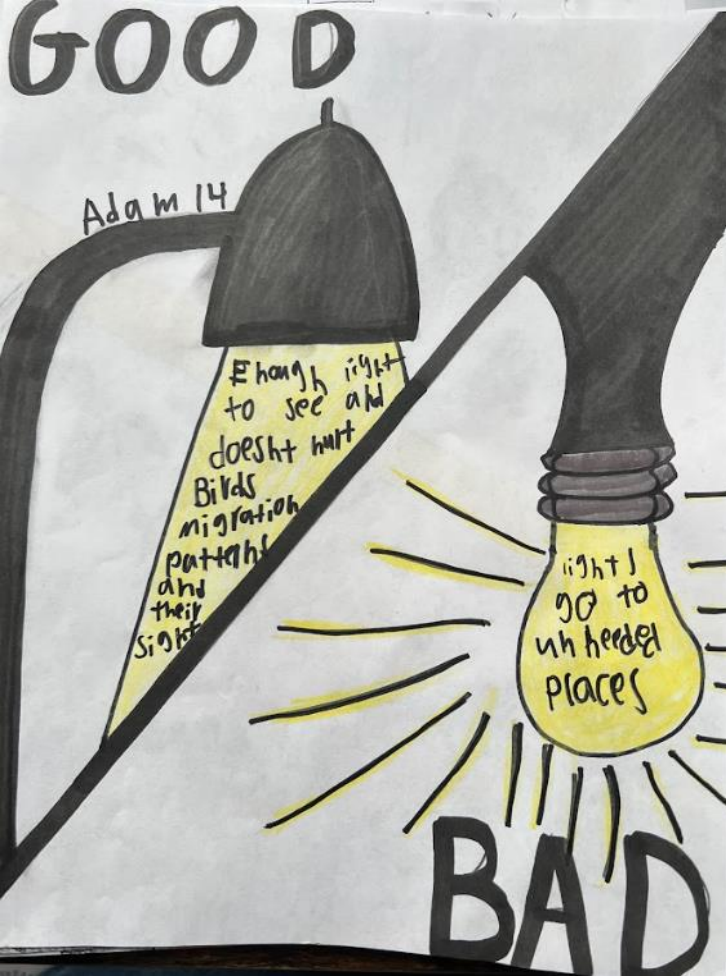


3. DarkSky Missouri engaged with school and dedicated teacher to do both in class lectures and activities; as well as outdoor field measurements and observations.
4. Goal is to provide science-based recommendations to campus and neighborhood regarding responsible outdoor lighting.
5. Wildlife cameras to track nocturnal and diurnal animals visiting campus.
6. Guest speakers from affiliates to educate and inform students about migration and outdoor lighting.



# CFM David Risberg Grant





- We need your time and financial support!
- We need your expertise to help craft more effective and consequential educational programs!  
*(...to implement CFMs 2025 resolution: "Advocating for Conservation Education to be added to the Missouri Learning Standards")*
- We need you to implement Dark Sky friendly Responsible outdoor light fixtures and lights!
- We would like to collaborate with you on your projects and include DS friendly elements to them!

# What we need from you

1. Become a member!

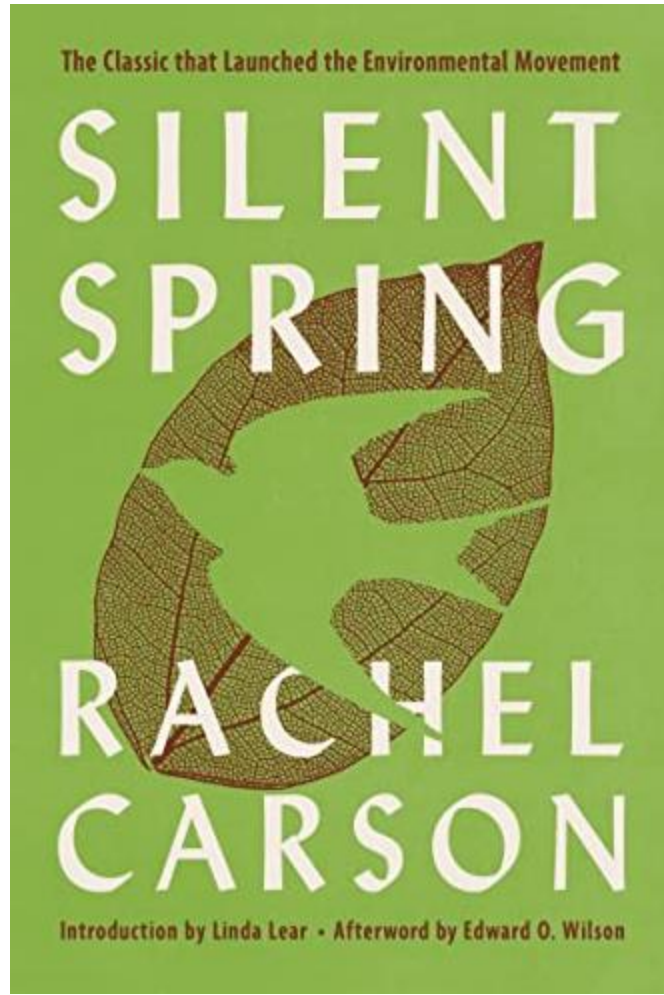
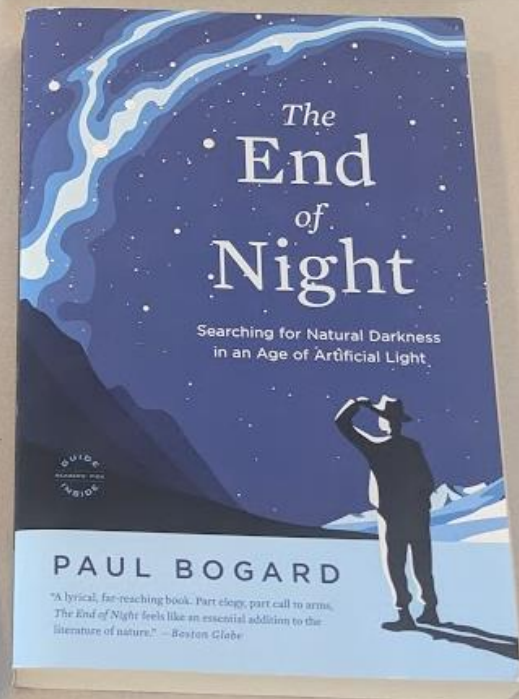
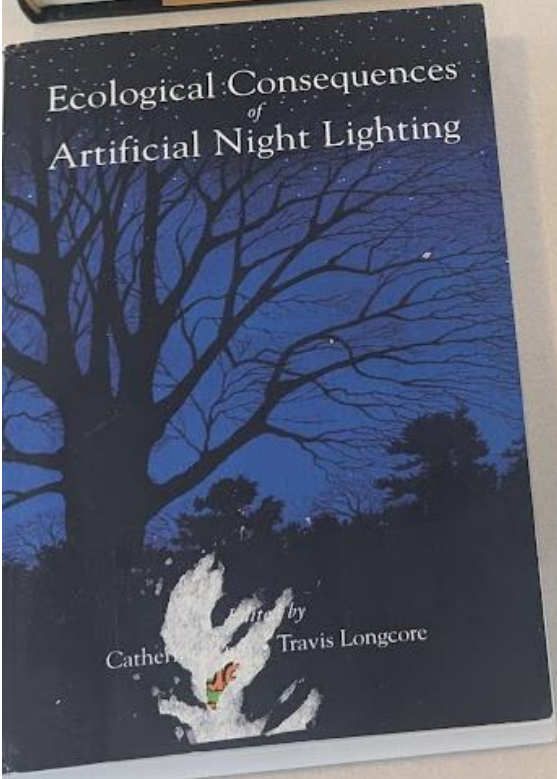
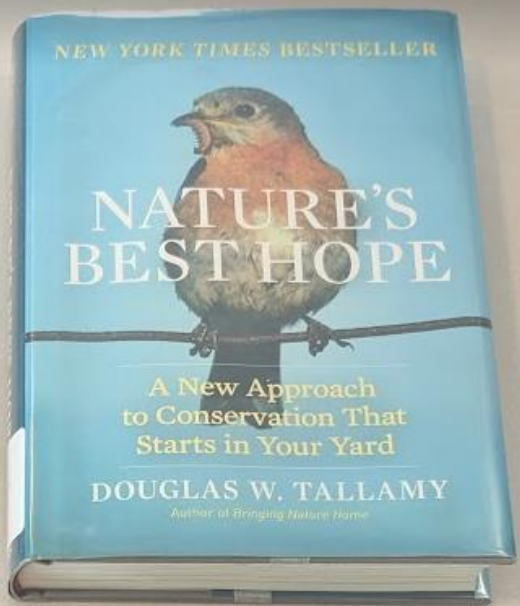
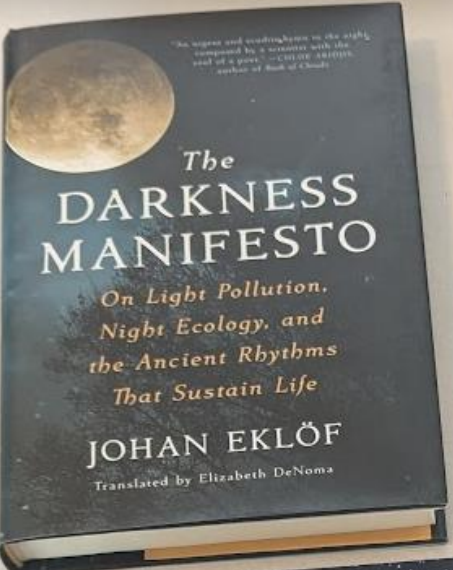


2. Bring your expertise and join a DarkSky Missouri committee:
- a) **Outreach**: Advocate for responsible lighting
  - b) **Engagement**: Help run newsletter, social media etc.
  - c) **University and School engagement**: Engage students
  - d) **Laws and Ordinances**: Engage lawmakers and policymakers
  - e) **Membership**: Help boost membership

3. Participate in our DarkSky Training program

# EXTRA SLIDES

# Reading Recommendations



Best practice lighting design incorporates the following design principles:

- 1) **Start with natural darkness** and only add light for specific purposes.
- 2) Use adaptive light controls to manage light timing, intensity and color.
- 3) Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill.
- 4) Use the lowest intensity lighting appropriate for the task.
- 5) Use non-reflective, dark-colored surfaces.
- 6) Use lights with reduced or filtered blue, violet and ultra-violet wavelengths.



# DarkSky Missouri: Board of Directors

- DarkSky Missouri is an official chapter of DarkSky International
- Six “Operating Zones”
- Board of Directors (13 currently)
- Board Officers (4)
- Nominating Committee
  
- Chapter Advisors (~10 spread over all Zones)



## DarkSky Missouri: Funding

- Donations,
- Membership dues,
- Grants.

## DarkSky Missouri: Expenses

- Registration for events and event organization
- Research: Quantifying causes and effects of Light Pollution
- Educational materials: Tabling, printing handouts & brochures etc.