

**Mitigate light pollution  
and protect our  
environment**

**Lincoln Dark Skies  
Committee**



The Dark Skies Committee is a subcommittee of the Planning Board

<https://www.lincolntown.org/1550/Dark-Skies-Subcommittee>

Dark Skies nominated Committee members

Louise Bergeron

Frank Clark

Buzz Constable

Sherry Haydock

Ken Hurd

Kathleen Lomatoski

Craig Nicholson

Diana Smith

Associates, Experts and Liaisons

Roy Harvey: Technical expert and energy Committee

Susan KatzSliski: Dark Skies advocate and school program

Diana Jong: LLCT and school program

Virginia Lemire: Commons

Robin Wilkerson: Common Grounds

Kathryn Walker: Writing and editing

Alan Sliski: Technical expert and Dark Skies advocate

Kim Bodnar: Select Board



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*If I cannot move heaven, I will raise hell. (Virgil, Aeneid)*

# Content

1. Why control light pollution?
  2. What are the concerns in Lincoln?
  3. Solutions through Town policies, bylaws and education
  4. Summary of outreach plan
  5. Technical information on Dark Skies friendly lighting
  6. Dark Skies Mission
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# Why control light pollution?

1. Support our ecosystems by improving the survival of mammals, amphibians, birds and insects
2. Protect our pollinators and improve food production on our farms
3. Enhance our safety and security
4. Protect our quality-of-life and human health
5. Reduce energy consumption
6. Enhance our ability to enjoy the starry night

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*The ravening clouds shall not long be victorious  
They shall not long possess the sky, they devour the stars only in apparition,  
Jupiter shall emerge, be patient, watch again another night, the Pleiades shall emerge. They are immortal.  
(Walt Whitman, Leaves of grass)*

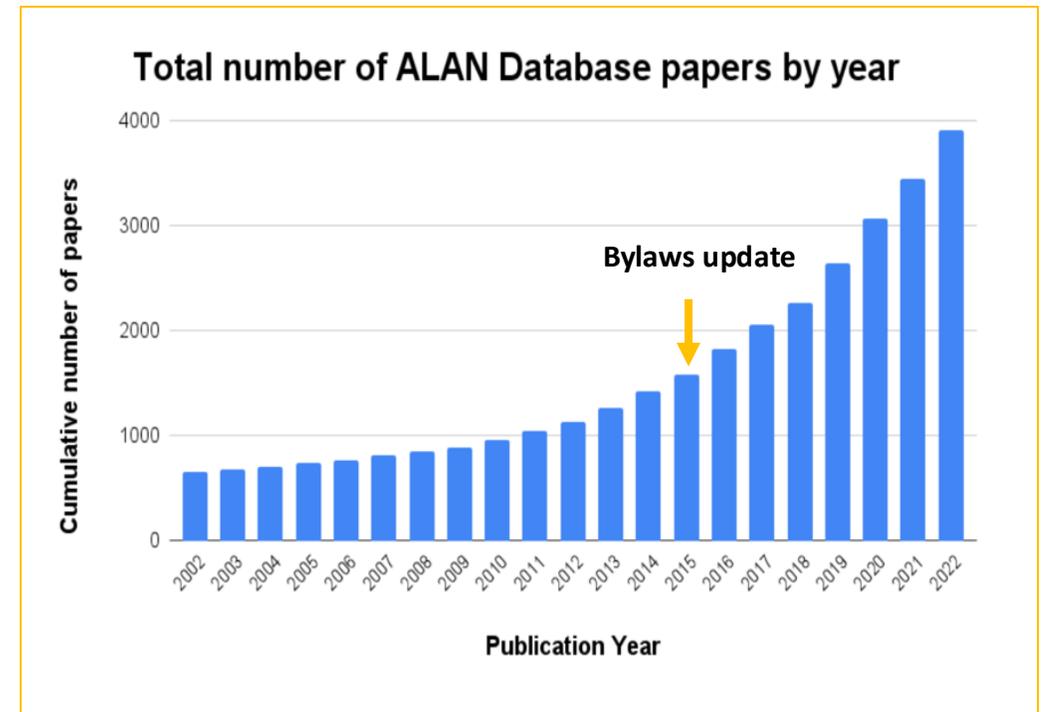
# Emerging science since last bylaws update

Since the invention of the LED, blue color light similar to day light has proliferated dramatically.

LED technology is both a problem and a solution.

Scientific evidence on the effects of artificial light on human, animals and insects is mounting.

ALAN: Artificial Light at Night

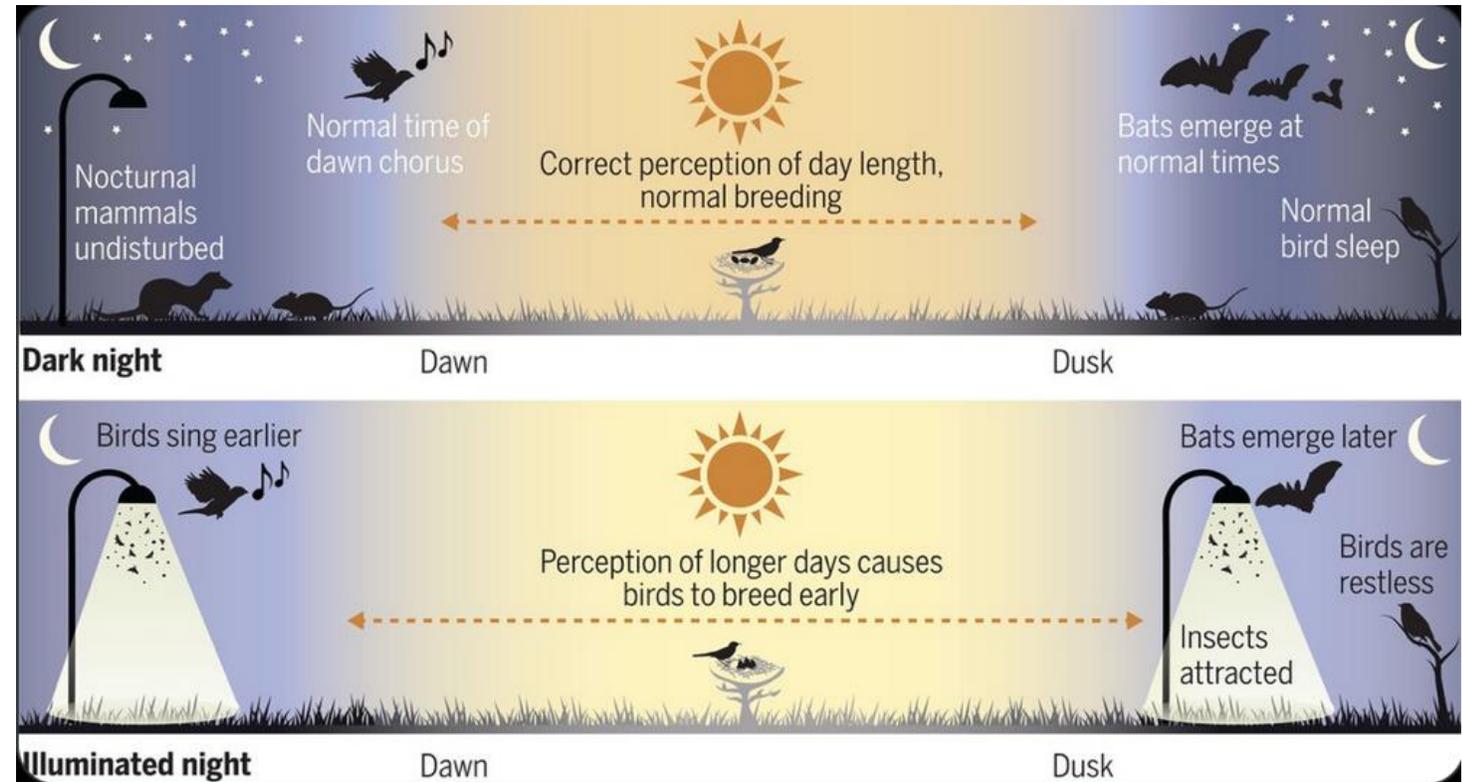


<https://darksky.org/news/artificial-light-at-night-state-of-the-science-2023-report/>

# Artificial light at night harms our fauna

- For billions of years, plants and animals have evolved with the earth cycles of night and day
- In the last century, humans have perturbed that cycle, endangering ecosystems.
- In the last twenty years, LED lights have brought daylight into the night.

- All animals, whether nocturnal or diurnal depend on circadian cycles for survival.
- Artificial light affects critical activities such as reproduction, foraging, hiding from predators, migration, and sleep.
- Animals stay away from our artificial light resulting in a reduction of their habitat already in decline.
- The glare of our lights interferes the nocturnal breeding activity of frogs, salamanders and toads and kill insects



Science Magazine, June 20, 2024

<https://darksky.org/resources/what-is-light-pollution%20/effects/wildlife-ecosystems>  
<https://darksky.org/news/artificial-light-at-night-state-of-the-science-2023-report/>

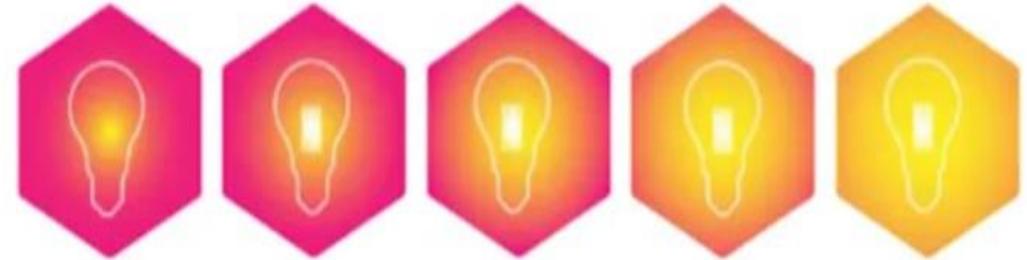
# Light intensity and color

## Light Color Temperature (Kelvin)



- Color temperature describes the hue of the light, it is measured in degrees of Kelvin
  - Candle flame: 1800K
  - Incandescent: 2700K
  - Operating room: 4000K
  - Day light: 5000K
  - Blue sky: 8000-10000K
- Blue rich light causes most glare and is the most disruptive to sleep and wildlife.

## Light intensity (Lumens)



- The light output of a source is measured in Lumens
  - Watts is the energy used to generate light.  
A 9-watt LED is equivalent to a 60 watts incandescent bulb
- How many lumens is needed depends use
  - 200-500 lumens is considered sufficient to illuminate an entrance way
  - Lincoln's outdoor lighting guidance restricts a light source to 900 lumens but does not limit the number of light sources
  - Illumination, measured in foot-candle or Lux, is what matters

<https://darksky.org/news/why-is-blue-light-at-night-bad>.

<https://nvlightingga.com/blog/how-bright-should-outdoor-lighting-be>

<https://www.streetlights-solar.com/how-many-lumens-do-i-need-for-outdoor-lighting.html>

# Birds need darkness to migrate and survive

- 80% of bird species migrate at night.
- Artificial light disorients and attracts them. It causes birds to wander off course and hit buildings.
- Among the one billion birds that die from flying into buildings in the USA each year, nearly half of them collide with homes and smaller buildings.



Owls are blinded by bright light; they stay away from artificial light which greatly limits their range.



When Worlds Collide' by Patricia Homonylo. Overall Winner and Bird Photographer of the Year 2024.

“When words collide”, Patricia Homonyla.  
Dead Birds that hit building during their migrations. The Smithsonian, 2016

<https://flap.org/>

<https://darksky.org/resources/what-is-light-pollution%20effects/wildlife-ecosystems/>

<https://darksky.org/news/artificial-light-at-night-state-of-the-science-2023-report/>

<https://www.pbs.org/newshour/science/how-light-pollution-can-imperil-migrating-birds-by-luring-them-into-cities>

# Lincoln farmers need the lights out

## Pollinators and other insects require darkness at night for survival

- The loss of pollinators affects our ability to produce food.
  - A study conducted in 2017 found that approximately 62% fewer insects visited the plants in a meadow illuminated at night with LED streetlamps than a meadow naturally lit by the moon.
  - Bees, which are diurnal, require darkness at night to forage effectively during the day
- Insects critical to the survival of many other species such as birds and bats.
- Nocturnal insects are fatally attracted to artificial light, leading to a serious decrease in their population.
- Fireflies cannot mate under our artificial light with even red light affecting them. Fireflies can still be found in Lincoln, in our darkest farm fields.



<https://darksky.org/resources/what-is-light-pollution%20/effects/wildlife-ecosystems/>

<https://darksky.org/news/artificial-light-at-night-state-of-the-science-2023-report/>

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*There was a star danced, and under that I was born. (William Shakespeare, Much Ado About Nothing)*

# Artificial light at night is harmful to human health

- Excessive light at night interferes with sleep patterns, and bright artificial light has been linked to an increased risk of stroke, Alzheimer's disease and cancer.
- Neighbors' or streetlight illuminating large areas deprive residents from the experience of darkness on their own property.



*Lincoln's library illuminates a private garden*

- We're All Healthier Under a Starry Sky, Mario Motta: [https://images.clubexpress.com/71141/attach/3935311\\_1\\_JOE-MarioMottapeerReview-10-2-24.pdf](https://images.clubexpress.com/71141/attach/3935311_1_JOE-MarioMottapeerReview-10-2-24.pdf)
- Mental and physical illness may be linked by a 'broken' circadian rhythm due to ALAN exposure. Su, K., et al. *Brain, Behavior, Immunity – Health*, Vol. 26, p. 100533.
- Excessive night lighting, especially blue light, leads to myriad deleterious health effects: <https://www.mariomottamd.com/street-lighting/>
- ALAN is associated with the prevalence of Alzheimer: <https://www.frontiersin.org/news/2024/09/06/light-pollution-increase-risk-alzheimers>
- Exposure to artificial bright light is linked to higher risks of strokes: <https://newsroom.heart.org/news/more-exposure-to-artificial-bright-outdoor-nighttime-light-linked-to-higher-stroke-ris>

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*The stars are the jewels of the night, and perchance surpass anything which day as to show (Henry David Thoreau)*

# Safety and security: More is not better

- Experts agree that there is no substantial evidence that lighter means safer. In fact, too much lighting and glare can negatively impact safety.
- Lower intensity, consistent lighting, where and when needed, and motion-activated lighting would improve safety and security.

Glare from bright, unshielded lights actually decreases safety. See how glare in the closest photo makes it hard to see the man at the gate? Glare creates deep shadows, making it more difficult to see. The bright light shines into your eyes, constricting your pupils. This diminishes your eyes' ability to adapt to low-light conditions. So, is that bright light really making this area safer?



Switching off street lighting during overnight hours can reduce instances of theft from vehicles parked along streets. Tompson, L., et al.

Bright LEDs could spell the end of dark skies. <https://www.technologyreview.com/2022/08/17/1057652/outdoor-led-lighting/>

Streetlights effects on crime: <https://www.theatlantic.com/ideas/archive/2024/09/streetlights-effect-on-crime/679652/>

*The stars that nature hung in heaven, and filled their lamps with everlasting oil, give due light to the misled and lonely traveler. (John Milton)*

# Some of the good and the to-be-improved in Lincoln

## Good Examples

- Codman Farms and estate (Fortunately, no picture could be taken because it is dark)

## Some area of concerns

- Institutions
  - School
  - Library
  - Churches
- South Lincoln mall area
  - Parking lots
  - Businesses
  - Signs
- Street lights
- Private properties
  - Landscape lighting
  - Doorway and porch lights
- Condo and rental properties

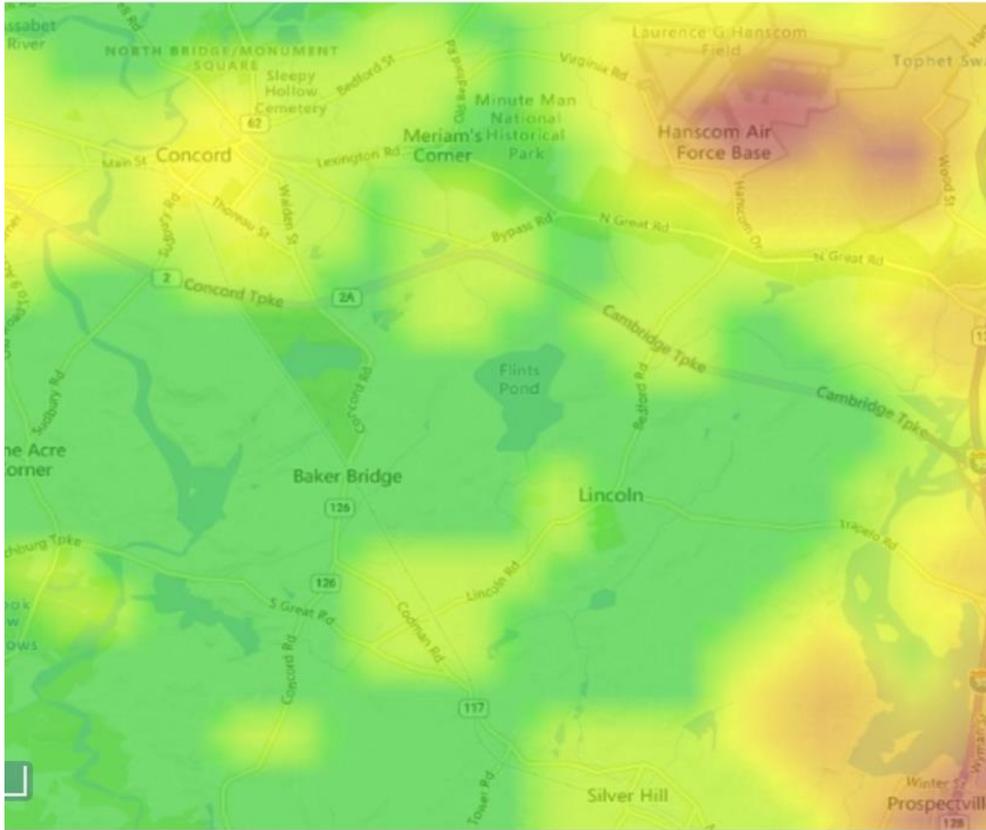


*When you reach for the stars you may not quite get one, but you won't come up with a handful of mud either. (Leo Burnett)*

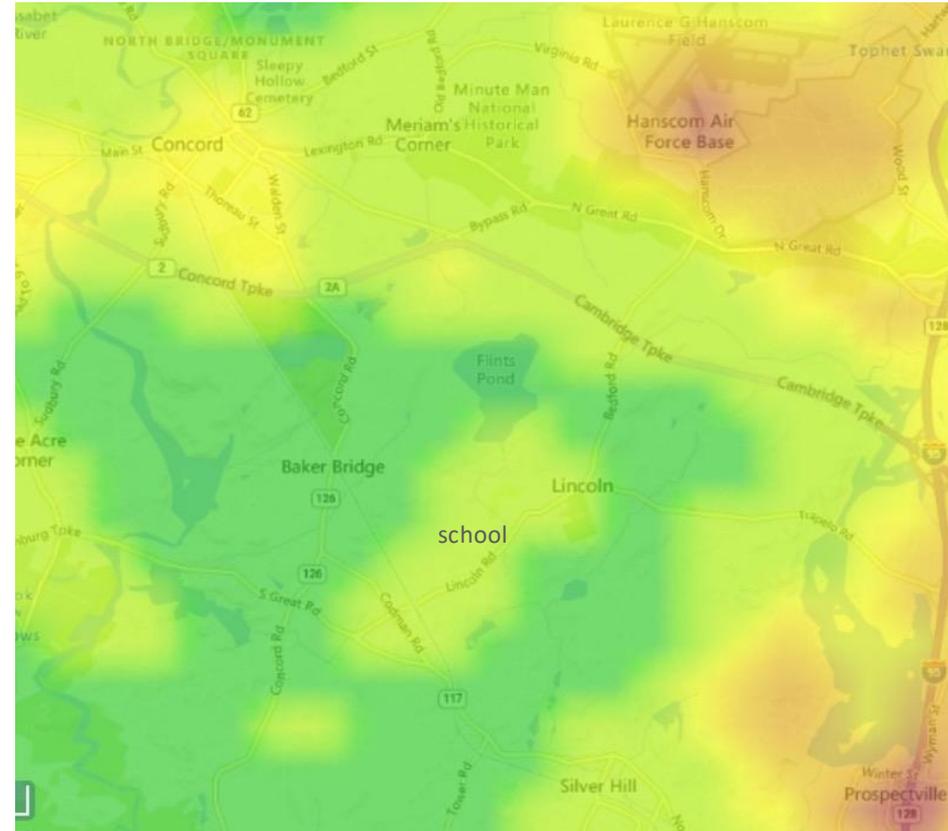
# Have our current zoning bylaws been sufficient?

- Light pollution has increased in Lincoln despite the adoption of new bylaws in 2012
- Not only we have more light but more blue light
- Development continues
- What are the main problems? What can we do to improve the situation?

2013



2023



# Apply International Dark Skies lighting guidelines

Five Lighting Principles for Responsible Outdoor Lighting		 DarkSky	
Responsible outdoor lighting is	<b>1 Useful</b>	<b>Use light only if it is needed</b> All light should have a clear purpose. Consider how the use of light will impact the area, including wildlife and their habitats.	
	<b>2 Targeted</b>	<b>Direct light so it falls only where it is needed</b> 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.	
	<b>3 Low Level</b>	<b>Light should be no brighter than necessary</b> Use the lowest light level required. Be mindful of surface conditions, as some surfaces may reflect more light into the night sky than intended.	
	<b>4 Controlled</b>	<b>Use light only when it is needed</b> 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.	
	<b>5 Warm-colored</b>	<b>Use warmer color lights where possible</b> Limit the amount of shorter wavelength (blue-violet) light to the least amount needed.	

Rev. 08-2023

<https://darksky.org/resources/guides-and-how-tos/lighting-principles/>

*Many a night I saw the Pleiades, rising thro' the mellow shade, Glitter like a swarm of fireflies tangled in a sliver braid. (Alfred Tennyson)*

# DarkSky Approved Luminaires and Bulbs



## Responsible Home outdoor lighting

- <https://darksky.org/what-we-do/advancing-responsible-outdoor-lighting/home/>

## **The easiest and best solution**

Turn off the lights when not in use.  
No need to have lights on all night.

## DarkSky approved luminaires

- <https://darksky.org/what-we-do/darksky-approved/luminaires/>
- <https://designlights.org/our-work/luna/>

### Search by Use

Store / Search by Use



Pathway



Deck and stair



Ceiling



Wall mount



Post top



Parking lot

## Some examples



Motion activated  
lights: \$40



Fully shielded entrance  
lights: \$50

## Light Bulbs

- [www.1000bulbs.com](http://www.1000bulbs.com)
- Choose 2700K or less
- Keep intensity to the level needed.
  - 200-500 Lumens is sufficient for an entrance way.
  - 900 lumens is the maximum allowed in Lincoln

# Lincoln's current exterior lighting bylaws and guidance

## Bylaws

- 13.5 Exterior Lighting: All artificial lighting permanently installed in any district, shall consist only of fully shielded light fixtures and be so installed or shielded as to prevent direct light or glare from the light source from interfering with the vision of motorists or pedestrians passing in the street or streets abutting the premises and as to prevent direct light or glare from illuminating neighboring properties.
- 13.5.1 All exterior lamps shall have a Correlated Color Temperature (CCT) value of 3000K or below.

## Guidelines for exterior lighting (Additional items added in 2015)

- Exterior lighting on structures will be allowed only where required by the Massachusetts Building Code or where the Planning Board determines that lighting is needed to enhance safety of occupants or visitors.
- Individual light fixtures shall not exceed 900 lumens.
- Exterior lighting of structures or landscape for architectural or aesthetic effect is not permitted.
- Driveway lighting will not be allowed; however, lighting in parking areas and walkways adjacent to a home may be allowed. Such lighting should be mounted no more than 3 feet above finished grade.
- To identify street numbers, reflective numbers on mailboxes are preferred. In unusual circumstances, the Planning Board may allow lighting of street numbers placed on the exterior of a residence or on a plaque or bollard placed near the street.

Existing fixtures prior to 2015 are exempt from this regulation

# Summary of Proposed General Bylaw

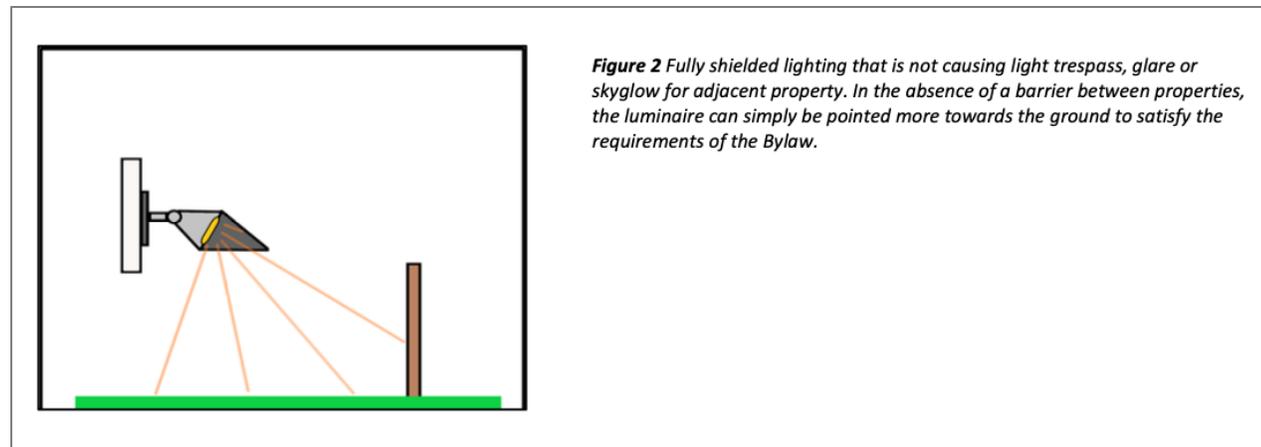
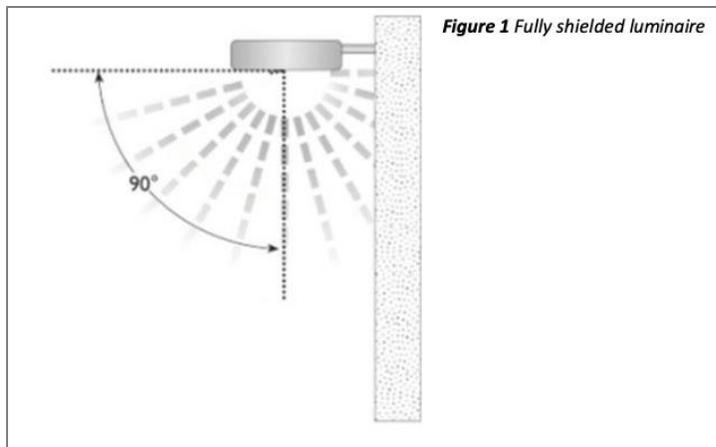
*The Planning Board can grant exceptions to those bylaw for safety or security reasons.*

## **Useful and Controlled Use light for a purpose and when needed**

- We recommend motion activation so that the light is only on when needed. Dim the light to the level that is required.
- Accent lighting, including landscape lighting, shall be focused directly at the target and shall not exceed 250 lumens per fixture and a total of 2000 lumens. Such lighting should be turned off or dimmed at 9:00 pm.

## **Targeted: Directed only where needed**

- Unless exempted, all exterior luminaires shall be fully shielded.



*When you reach for the stars you may not quite get one, but you won't come up with a handful of mud either. (Leo Burnet)*

# Summary of Proposed General Bylaw

*The Planning Board can grant exceptions to those bylaw for safety or security reasons.*

## **Low level, not brighter than necessary**

- Maximum of 900 lumens per fixture with limited lumens/property to 10,000 lumens  
    We recommend not using more light then needed: example: 200-500 lumens in entrance ways
- Tress pass light: One cannot illuminate neighboring properties

## **Warm colored**

- The correlated color temperature (*CCT*), of the light emitted by the luminaires shall not exceed 2700K.

## **Street lights and Public Buildings**

- We propose that the town evaluates the cost and feasibility of bringing public lighting in compliance with those general By-laws.
- We propose to turn off or dim street lights that are a nuisance or not needed.

## **Implementation**

- All non-conforming *luminaires* shall be brought into conformance within five (5) years of adoption of this By-law for property owned by the Town or other public governmental agencies, within five (5) years of adoption of this By-law for other property, and ten (10) years for property containing only a single- or two-family dwelling.

# Our advisors

## ➤ Experts who provided resource and guidance

- Glenn Heinmiller: Professional lighting designer, co-author of the statewide Dark Sky Bill now pending in the legislature, helped write Nantucket's new lighting bylaw.
- Tim Brothers: Astronomer at MIT's Wallace Observatory in Westford, resident of Pepperell and co-author of the Dark Sky Bill.
- Leo Smith: Member of Illuminating Engineering Society, author of DarkSky International's Model Lighting Bylaw
- Jane Slade: Professional lighting designer in Mass., very familiar with dark-sky principles
- James Lowenthal : Professor of Astronomy, Smith College. Consulting on lighting bylaws for the towns of Pelham, Amherst, Northampton. Working with DarkSky International to develop a new municipal lighting bylaw template.
- Gail Walker: Heads Nantucket Light. Expertise in advocacy and bylaw writing.

## ➤ Key documents that can serve as models of bylaws, town policies and education campaigns

- Nantucket: Bylaws and Educational materials
- Outdoor Lighting Bylaw for Pepperell MA
- Model of Outdoor Lighting Regulation, 2024 CT
- MA-Contemporary Outdoor-Lighting Bylaw v1.0 2023-08-25

# Video to watch

Presentations from James Lowenthal, Smith College

<https://www.youtube.com/watch?v=MIHp-B0DTMw>

[https://www.youtube.com/watch?v=k\\_mZignBh6c](https://www.youtube.com/watch?v=k_mZignBh6c)

Presentation from Tim Brothers

<https://www.youtube.com/watch?v=R8HKaye8Uog>

DarkSky International

<https://darksky.org/what-we-do/advancing-responsible-outdoor-lighting/home/>

Contact the Lincoln Dark Skies Committee:

craig Nicholson: [NicholsonC@lincolntown.org](mailto:NicholsonC@lincolntown.org)

# Dark Skies mission

Honoring its history as a rural, by-right farming community and its legacy of leadership in land conservation, Lincoln seeks through education and practice to further protect the natural environment by better understanding and mitigating the adverse effects of excessive artificial light on the natural world and its nocturnal wildlife.

Drawing upon both scientific research and the lived experience as a mixed suburban/agricultural community, the Town aspires to be a municipal leader in embracing the principles of the Dark Sky initiative by using a commonsense approach to preserving and protecting the night sky ambience that enhances the general well-being of residents as well as Lincoln's nocturnal wildlife. Adopting current best practices of exterior lighting will only amplify the Town's commitment to maintaining a more natural, sustainable environment in which all inhabitants including flora and fauna may thrive.

International and MA Dark Sky initiatives

<https://darksky.org/>

<https://darksnymass.org/about-us/idas-massachusetts-chapter/>

# Dark Skies purpose

In accordance with our Mission Statement, current and future outdoor lighting systems should be designed, constructed, installed, and maintained to:

1. Minimize *light pollution* and especially *blue light*, to the greatest extent possible in all outdoor lighting, as it is known to cause negative effects on human health, road visibility, agricultural yields, the well-being of birds that migrate at night as well as all the nocturnal organisms, including pollinators, bats, turtles, fish and amphibians, especially salamanders, frogs and toads.
2. Protect residents from unwanted light, or *light trespass*, that negatively affects the enjoyment of their own property, including their property values.
3. Control and mitigate *glare* to increase the safety and security of residents, visitors, motorists, pedestrians and our nocturnal inhabitants, all of which can be blinded and disoriented by undue glare.
4. Provide adequate light for the safe performance of outdoor tasks at night.
5. Preserve the historic and rural character of Lincoln for current and future generations.
6. Minimize *skyglow* to preserve the ability to see the stars, the constellations and the Milky Way galaxy against a dark sky, thus allowing the ancient art of star gazing that has captured the imagination of every culture since time began for humans on earth.
7. Promote efficient and cost-effective lighting to conserve energy.