

**Mitigate light pollution
and protect our
environment**

**Lincoln Dark Skies
Committee**



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

*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)*

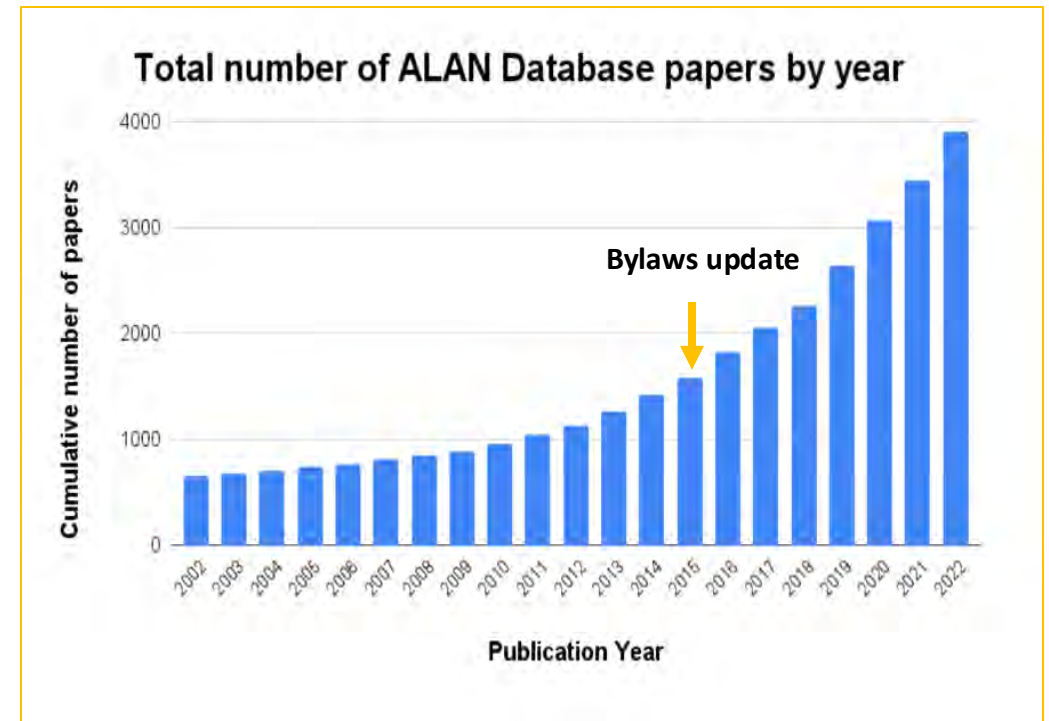
Emerging science since last bylaws update

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

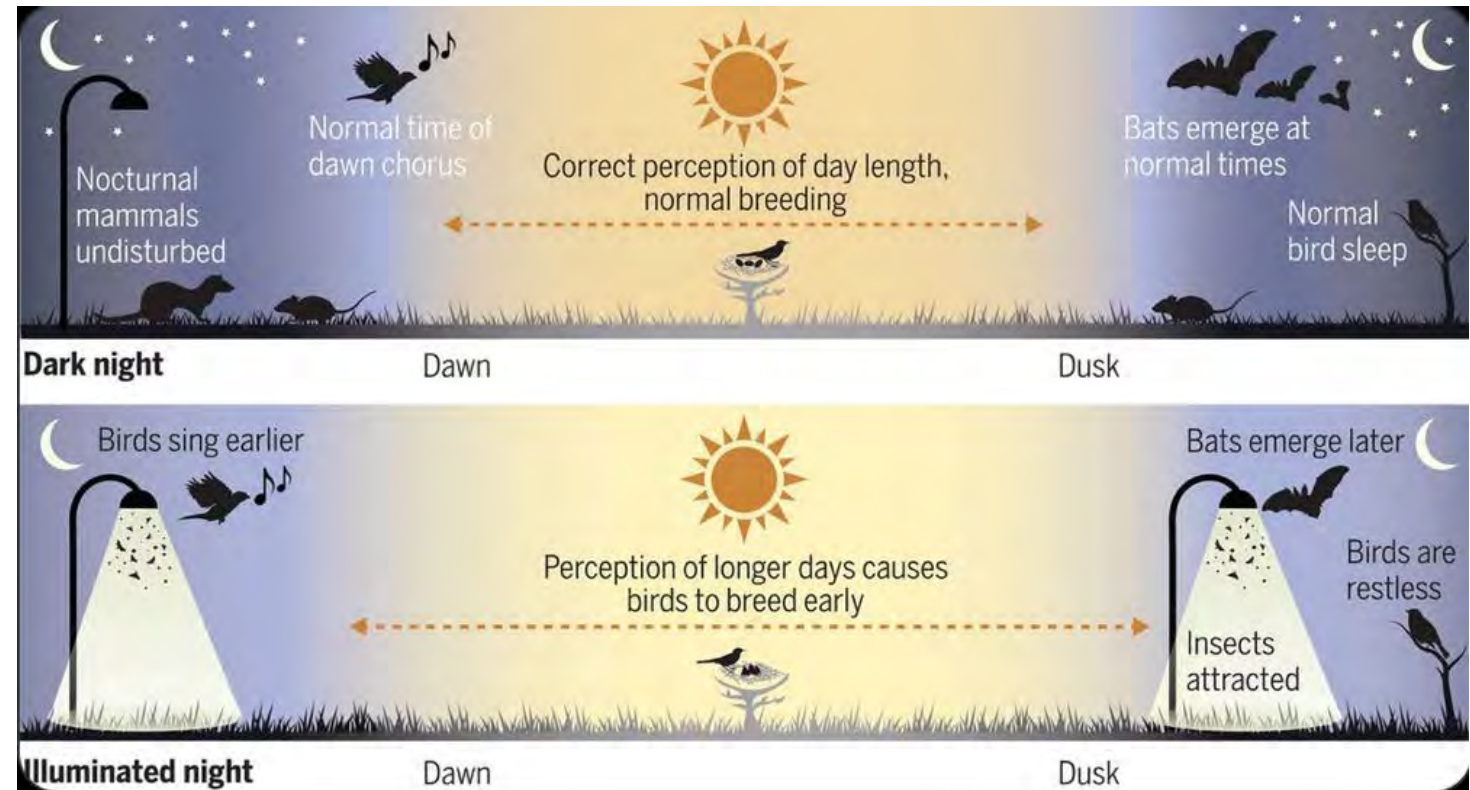


<https://darksky.org/news/artificial-light-at-night-state-of-the-science-2023-report/>

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
 - Day light: 5000K
 - Blue sky: 8008-10000K
- 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
- The illumination, measured in Lux, is what truly 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 Homonyla. 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/>

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
- 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>

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)

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)

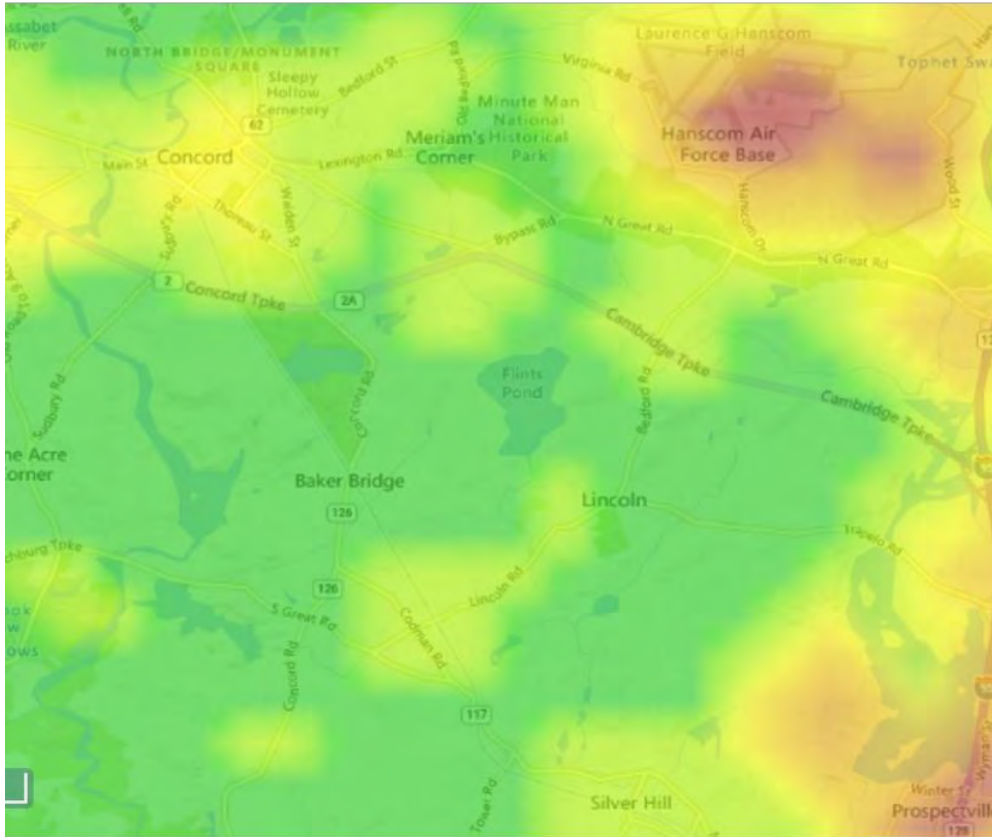
- Exterior lighting on structures will be allowed only where required by the Massachusetts Building Code or where the Planning Board determines that lighting is needed to enhance safety of occupants or visitors.
- Individual light fixtures shall not exceed 900 lumens.
- Exterior lighting of structures 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

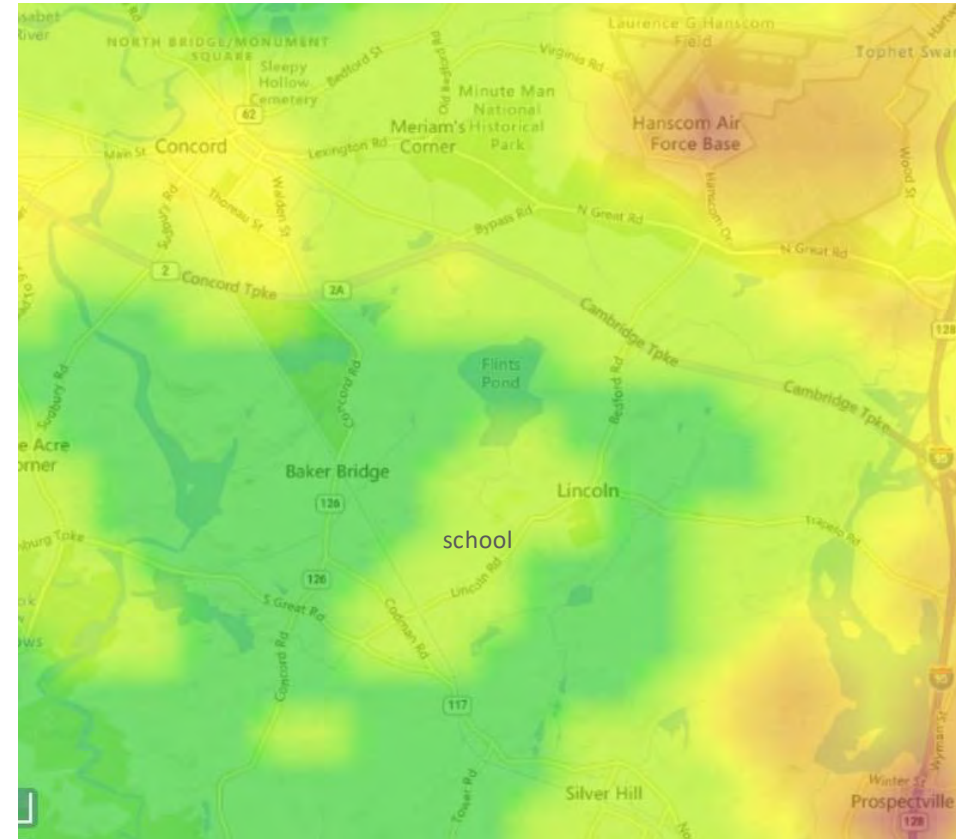
Have our current zoning bylaws been sufficient?

- 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



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
 - Some churches
- South Lincoln mall area
 - Parking lots
 - Businesses
- Streetlights
- Private properties
 - Landscape lighting
 - Doorway and porch lights
- Condo properties
 - Lincoln Ridge
 - Ryan Estate



Current guidelines versus considered lighting changes

Current

General Bylaw or town policies

- Non-existent

Zoning Bylaw

- Fixtures shielded to avoid up-lighting or off-site shining
- Maximum color temperature 3000K
- Existing fixtures prior top 2015 are exempt from this regulation

Guidance

- Maximum intensity per fixture 900 Lumens
- Driveway lighting not 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.

Considered

Public light (policies or bylaws)

- Street lights: fewer lights, color 2700K or lower, reduce intensity
- Parking lots: Red light, 2500K or lower, motion activated from 100-900 lumens
- Buildings: Lights off after hours, except for one light of 200-500 lumens at the entrance, 2700 K or lower.

General Bylaw applicable to all parcels (New)

- Color temperature **2700K or lower**
- **Turn off by 11:00 pm or turn at 9:00 pm with motion activation**
- Maximum 900 lumens
- **Parking and driveway, red light, 2500K or lower, motion activated 100-900**
- Fixtures shielded to avoid up-lighting or off-site shining
- **Commercial** and Institutional properties should have all signs visible from outside the structures meeting the Guidelines or other requirements of zoning regulators.
- Special events and exceptions permitted by the planning Board in the best interest of the public
- Landscape lighting : TBD
- **5 years to comply**

Zoning Bylaw

- Variance, or site plan approval should comply with general bylaw.

Apply International Dark Skies lighting guidelines

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.	

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)

Guidance from experts and model bylaws

➤ 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

Outreach Plan

Type	Organization	Date
Town departments	DPW and Tim Higgins	Unclear
	Public Safety, Sean Kennedy Town Facility Director, Brendon Kelly	Oct 2024
	Library	Oct 24
Board and Commissions	Planning Board	Oct 2024, January 2025
	Select Board	Nov 18
	Conservation Commission	Nov 20
	Historical Commission,	Oct
	Board of Health, Bicycle and Pedestrian Committee	To be scheduled
Resident groups and institutions	Common Ground, LLCT	Oct 2024
	Mass Audubon	
Residents	SOTT	Dec 7
	Presentation and meeting with Dark Skies Committee	Dec 18 or Jan 8 (TBD)
	Presentation and discussion at Bemis Hall	Jan 15-29 (TBD)

It is not in the stars to hold our destiny but in ourselves. (William Shakespeare)

Draft Dark Skies Plan Outline

1. **PUBLIC LIGHTS** [Note: all of the bullets in this section could be accomplished administratively now or included in a bylaw.]
 - Lighting in Publicly Owned Parking and recreation Areas and Exterior to Buildings
 - Street Lights
 - Interior Lights on Public Buildings

2. **GENERAL BYLAW APPLICABLE TO ALL PARCELS** (except state, federal and state-wide authorities)
 - New Construction or Installation
 - Existing Structures and Fixtures
 - The Board of Selects may waive or suspend Dark Skies requirements for an emergency or for an event or condition when, after a public hearing, it determines such waiver or suspension to be in the public interest.

3. **ZONING BYLAW**
 - The Zoning Bylaw would provide that applications subject to a special permit, variance, or site plan approval shall comply with the Dark Skies Bylaw.
 - The Planning Board and Zoning Board of Appeals would retain its jurisdiction, including discretion to impose additional conditions that relate to lighting.
 - The Zoning Codes Enforcement officer would be the primary enforcement officer, with appeals from their decision to be made to the Zoning Board of Appeals as currently provided for zoning matters.

4. **EDUCATIONAL RESOURCES**
 - The Town would make available a list of the best dark skies lighting fixtures and retrofits with approximate costs for anyone who wants to look, including applicants for zoning approvals. Update the list at least every two years.
 - The Town would provide educational materials for homeowners moving to Lincoln, *a la* LLCT/ConsCom.

The Dark Skies Committee is a subcommittee of the Planning Board

<https://www.lincolntown.org/252/Planning>

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



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

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.