

PRESERVING DARK SKIES

- Draft Chapter From: *Innovative Land Use Planning Techniques* -

Related Tool: *Wildlife Habitat Management, Energy-efficient Development, Pedestrian-oriented Development*

Background and Purpose:

The dark, star-filled night skies that still prevail in New Hampshire's extensive rural areas are an important but diminishing natural resource. The pale arc of the Milky Way, the constellations, bright planets and an occasional passing comet that are easily seen on moonless nights form an essential component of the state's rural character – and a part of nature now lost to most Americans who live in densely lighted urban areas where “light pollution” washes out the stars.

New Hampshire's dark skies have more than esthetic value. They are part of the rural experience that attracts tourism, which in turn contributes significantly to local economies. By taking relatively simple steps to regulate outdoor lighting, communities may also save energy and minimize the impact of artificial light on wildlife habitat, where darkness is essential to predation, migration and reproduction of many nocturnal species.

When properly designed, outdoor lighting can meet a community's needs for safety and security while helping to preserve or enhance its rural character. Well-designed lighting also prevents potentially dangerous roadway glare and “light trespass,” the unwanted intrusion of a neighbor's lighting across property lines. In addition, by requiring that newly installed outdoor lights emit the minimum amount of illumination recommended by industry standards for a given purpose – whether parking lots, streetlighting or building security – communities can encourage energy conservation.

Lighting regulations, which may take the form of a local ordinance or provisions in a planning board's site plan review and subdivision rules, can mitigate the impact of light pollution and encourage energy savings with little or no burden of public cost or inconvenience.

Appropriate Circumstances and Context of Use

Dark-sky regulations are appropriate for any area where preserving, enhancing or restoring rural character is desired, or where excessive artificial lighting may impact wildlife.

According to studies cited by the 2006 Wildlife Action Plan prepared by the New Hampshire Fish and Game Department, biologists have found that bright artificial lights can be harmful to a

wide spectrum of wildlife, including migratory birds, nocturnal amphibians such as frogs and salamanders and valued insects.

The Wildlife Action Plan notes that New Hampshire's fragile pine barrens or pitchpine habitat, where a number of rare and endangered moth and butterfly species are found, including the Karner Blue butterfly, is particularly vulnerable to bright artificial lighting that may disturb the reproductive cycles of these insects and increase their predation by birds and bats.

On the esthetic side, the visibility of stars is impaired by "light pollution." It is caused primarily by stray upward illumination from poorly designed outdoor lighting. Upward-beamed light reflects off dust particles and fine water droplets in the atmosphere to cause "sky glow" that can be brighter than the stars. Sky glow can be seen when driving in the dark countryside toward a brightly-lit urban area, where a bowl of light appears to hover over the distant city.

In most smaller New Hampshire communities, light pollution comes mainly from the illumination of commercial and public buildings – parking lot and security flood lights, store signs and the illumination of building exteriors – and from streetlighting. Privately installed area or yard lights at individual homes may also contribute to light pollution, but the small size and often dispersed nature of rural populations tends to diminish the harmful collective effects of residential lighting. "Light trespass," or nuisance lighting, such as a yard light shining into a neighbor's windows, is a more common problem.



Well-Shielded Lighting Illuminates the Ossipee Public Library (Photo – R Gillette)

Local lighting regulations commonly address the type and design of commercial, public and, in some cases, private residential lighting. In recent years, both the types and fixture design of outdoor lighting have evolved rapidly. Whereas once the dominant type of outdoor lighting was a 175 to 250 watt mercury vapor bulb that cast a white glow tinted blue-green, area lighting and streetlighting now comes predominantly from high-pressure sodium fixtures (producing an orange-pink light) and metal-halide (producing white light).

[MARGIN NOTE or Text Box: Shielding Lights – Terminology

Lighting designers generally identify four degrees of shielding in outdoor lighting fixtures or "luminaires" (a fixture and its bulb), depending on the amount of light they emit upward and at a high angle.

- **Full Cutoff: Zero light emitted above a horizontal plane drawn through the lowest part of the luminaire; no more than 10 percent of light emitted at the 80 degree angle. Also known as “fully shielded.”**
- **Cutoff: 2.5 percent of light or less emitted upward; 10 percent or less emitted at the 80 degree angle.**
- **Semi-Cutoff: 5 percent of light or less emitted upward; 20 percent or less emitted at the 80 degree angle.**
- **Non-Cutoff: No limits.]**

These designs are far more energy-efficient than mercury vapor or traditional incandescent lights, producing a given amount of illumination using 50 to 80 percent less electricity. Moreover, spent mercury vapor bulbs must be treated as toxic waste, and are now banned by some states and local communities. On the near-horizon, still being tested in commercial and roadway projects, are LED (light-emitting diode) fixtures for commercial and street lighting, which promise still greater energy efficiency.

In addition to bulb type, outdoor lighting is also defined by the extent to which the fixture shields the bulb in order to direct light downward to the ground, where it is needed (See margin note).

For example, the most common type of streetlight, and the New Hampshire Department of Transportation’s standard installation along state highways, is a 175-watt high-pressure sodium semi-cutoff “cobra-head” fixture, so named for its resemblance to the snake. “Semi-cutoff” means that 5 percent of the light is allowed to radiate upward, and 20 percent is cast at a high angle – 80 degrees, or nearly horizontally – so as to maximize the fixture’s illumination footprint.

Increasingly, local communities in New Hampshire and elsewhere are requiring the use of *full-cutoff* lighting for commercial and roadway lighting, and in some cases for outdoor residential lighting. A full-cutoff fixture has a slightly narrower footprint of illumination than the semi-cutoff at a given height above ground, but allows no upward light emission, and casts no more than 10 percent of its light at a high (80 degree) angle, thereby reducing lateral glare, energy loss and sky-glow.

Many fixture designs that meet full-cutoff (sometimes called “dark-sky friendly”) standards are now on the market, in both modern and traditional or historic styles. As there is essentially no cost difference between full-cutoff and less well-shielded designs, regulations requiring full-cutoff lighting impose no additional cost for compliance, while promoting more efficient use of energy.



**Full-Cutoff “Dark-Sky Friendly”
Yard Light**

Since the early 1900s, the Illuminating Engineering Society of North America (IESNA) has developed lighting standards in step with evolving technologies. Its standards are universally accepted by architects, engineers, safety designers and most advocates of preserving dark skies. The society produces guidelines for good, efficient lighting that are easily understood by laymen.

The New Hampshire Office of Energy and Planning (OEP) published an informative guide to efficient outdoor lighting in its Technical Bulletin 16 in 2001, re-issued in 2007. Information about lighting ordinances around the country and specifically in New England can be obtained from the International Dark Sky Association, an organization of amateur astronomers and educators, and the New England Light Pollution Advisory Group.

To visualize a community's level of light pollution, the free internet service GoogleEarth provides a "night-sky view" of any location, with an overlay of local sky glow derived from NASA satellite images.

Legal Basis and Considerations for New Hampshire

At the state level, only RSA 236:55 addresses the impact of outdoor lighting. This statute relates only road safety, rather than preservation of dark skies. It requires the Commissioner of Transportation and municipal board of selectmen to prohibit the placing of "any light along a highway so positioned as to blind or dazzle the vision of travelers on the adjacent highway."

Many local zoning ordinances incorporate this prohibition on roadway glare, and also regulate light-trespass or nuisance light across property lines. According to the OEP, as of 2007 at least 30 New Hampshire municipalities have incorporated broader outdoor lighting regulations, either in the form of zoning or other ordinances or in planning board regulations. Most of these regulations specifically address preservation of dark skies.

Outdoor lighting regulations may be included in site plan review or subdivision regulations adopted by local planning boards. However, planning board regulations pertain only to site-specific designs of new development projects, not to new lighting that may be installed at existing businesses or residences, and so may not address the cumulative effects of light pollution as effectively as a town ordinance.

In larger towns and urban areas, lighting regulations may need to be more detailed and varied according to the needs and character of specific areas, such as industrial or heavily trafficked commercial zones in contrast with residential areas where less illumination is needed. In such cases, a municipality should consider adapting regulations from a comparably-sized location in consultation with a lighting engineer.

For most New Hampshire towns, however, effective outdoor lighting regulations may be comparatively brief, simple and uniformly applicable throughout the town.

Although municipal and state highway lighting fall outside the authority of such regulations, there are important opportunities for communities to install more energy efficient, fully shielded streetlighting to reduce costs and help preserve dark skies.

Public Service of New Hampshire, serving 70 percent of New Hampshire, offers municipalities a “SmartStart” program to replace older town streetlighting with more energy efficient high-pressure sodium or metal halide lights at no up-front cost. The cost of the new lighting is paid through resulting energy savings, and is the same for both full-cutoff and semi-cutoff fixtures. Thus dark-sky friendly streetlights cost no more than those emitting stray upward light.

In early 2008, for example, PSNH replaced the town of Ossipee’s 108 streetlights – a mix of old-fashioned incandescent lights, older sodium-vapor and mercury vapor lights – with an equal number of 70-watt metal-halide (white light), dark-sky compliant fixtures. The \$51,000 cost of the replacement project will be paid over seven years by a 39 percent annual energy saving.

The New Hampshire Electric Cooperative (NHEC), the second largest utility serving 11 percent of the state, has gone a step further by adopting a policy of providing only dark-sky compliant, full-cutoff streetlights and private floodlights. NHEC is currently engaged in a long-term replacement program for existing lights at no additional cost to municipalities.

In addition, NHDOT customarily consults with local town administrations before installing new streetlights at state highway intersections, and has expressed willingness to install full-cutoff fixtures if requested.

Examples of Where Technique Has Been Applied

Outdoor lighting regulations currently in effect in New Hampshire tend to share several features in common.

- **Statement of Purpose**, outlining the public good the regulations is meant to serve. Chichester’s zoning ordinance, for instance, states that, *“The intent of this ordinance is to improve visibility of the nighttime sky without impacting safety, by reducing lighting conditions including but not limited to glare, light trespass and sky glow.”*

Wilton’s zoning ordinance states in part that its lighting ordinance is intended to *“preserve the rural atmosphere and dark skies of Wilton”* and notes that, *“Natural dark skies are the nighttime aspect of rural character. Increasing light pollution and glare from inappropriate lighting degrades such rural character.”*

- **Prohibition of Upward Illumination:** The most recent local ordinances require that all new lighting fixtures (luminaires) be fully shielded so as to emit zero light above a horizontal plane drawn through the lowest light-emitting part of a luminaire. Others require that all new outdoor lighting (some specify only commercial or institutional lighting) comply with IESNA standards for full-cutoff lighting.

- **Exceptions:** Local lighting regulations exempt emergency or temporary construction lighting; lighting required by state or federal regulations (as on transmission towers); and seasonal decorative and flag illumination. Towns that include residential lighting in such regulations usually exempt lights emitting less than 1,800 lumens, the light output equivalent of a 100-watt incandescent bulb.
- **Minimum Illumination:** By requiring that outdoor lighting use the minimum level of illumination recommended by the IESNA for a given purpose, regulations encourage energy conservation and prevent competitive “light escalation” among businesses that seek to illuminate signs and store fronts no less robustly than a neighboring business.
- **Grandfathering Existing Installations:** Regulations apply to new and (in the case of local ordinances) replacement lighting, but not to existing lighting. However, some local ordinances do require commercial signage to be brought into compliance within a specific period, such as three years.
- **Lighting Plan Required:** When lighting requirements are part of site plan or subdivision regulations, it is common to require an applicant to submit a lighting plan showing compliance with the regulations.
- **Other Features:** Some local regulations prohibit internally lit signs and allow only downward-pointing external sign lighting. Some specifically require gas station lighting to be located entirely under the pump canopy and recessed into the ceiling. Others require parking lot illumination to be dimmed or turned off after business hours, usually by 11 p.m. or midnight. Some regulations also specify maximum pole height for outdoor lights, with a formula for reducing pole height as property lines are approached.

The following examples of outdoor light regulations illustrate the range of detail and scope currently found among New Hampshire communities.

- **Peterborough:** Detailed and comparatively complex standards prohibit all upward lighting and set differing maximum levels of outdoor illumination in commercial and village areas as opposed to residential and rural areas. Outdoor lighting provisions in Peterborough’s zoning ordinance provide a model for larger towns and urban areas.
- **Raymond:** Site plan review design standards for lighting apply to all commercial and multi-family developments, but not single-family residences. The standards require the use of full-cutoff light fixtures, with no upward lighting allowed.
- **Shelburne:** Shelburne provides an example of how a simple lighting ordinance might be implemented in a small town. Requirements for outdoor lighting are as follows: *“All outdoor lighting shall be controlled to minimize the spillover of light onto adjacent properties. All outdoor area (non-decorative) lighting shall be aimed below the horizontal plane except for non-directional residential lighting such as porch, driveway*

and walkway lights.” Although brief, this regulation addresses problems of light trespass, glare and preservation of dark skies.

Model Language, Illustrations, and Guidance for Implementation

This model outdoor lighting ordinance is intended to be included in the municipal zoning regulations of small or medium-sized town. A municipality may decide to adapt this zoning ordinance as written, or it may chose to supplement this document with additional design standards placed in site plan review regulations.

Larger municipalities may wish to consult the more detailed example of outdoor lighting provisions in the zoning ordinances of Peterborough or Nashua, with the provision that full-cutoff fixtures be required. (Nashua allows upward light of up to 3 percent, thus allowing semi-cutoff fixtures.)

MODEL ORDINANCE FOR OUTDOOR LIGHTING:

Lighting Requirements:

All public and private outdoor lighting installed in the Town of _____ shall comply with the requirements specified below.

I. PURPOSE

The intent of this ordinance is to maintain the rural character of [town], in part by preserving the visibility of night-time skies, and to minimize the impact of artificial lighting on nocturnal wildlife. This ordinance recognizes the importance of lighting for safety and security while encouraging energy efficiency, and promotes good neighborly relations by preventing glare from outdoor lights from intruding on nearby properties or posing a hazard to pedestrians or drivers.

II. DEFINITIONS

Direct Light – Light emitted directly from the lamp, off of the reflector or reflector diffuser, or through the refractor or diffuser lens, of a luminaire.

Fixture – The assembly that houses the lamp or lamps and can include all or some of the following parts: a housing, a mounting bracket or pole socket, a lamp holder, a ballast, a reflector or mirror, and/or a refractor or lens.

Lamp – The component of a luminaire that produces the actual light.

Luminaire – A complete lighting assembly that includes the fixture and its lamp or lamps.

Flood or Spotlight – Any light fixture or lamp that incorporates a reflector or a refractor to concentrate the light output into a directed beam in a particular direction.

Glare – Light emitting from a luminaire with intensity great enough to reduce a viewer’s ability to see and, in extreme cases, causing momentary blindness.

Height of Luminaire – The height of a luminaire shall be the vertical distance from the ground directly below the centerline of the luminaire to the lowest direct-light-emitting part of the luminaire.

IESNA – Illuminating Engineering Society of North America.

Indirect Light – Direct light that has been reflected or has scattered off of other surfaces.

Light Trespass – The shining of light produced by a luminaire beyond the boundaries of the property on which it is located.

Lumen – A unit of luminous flux. One foot candle is one lumen per square foot. For the purposes of this ordinance, the lumen-output values shall be the initial lumen output rating of a lamp.

Outdoor Lighting – The night-time illumination of an outside area or object by any manmade device located outdoors that produces light by any means.

Temporary Outdoor Lighting – The specific illumination of an outside area or object by any manmade device located outdoors that produces light by any means for a period of less than seven days with at least 180 days passing before being used again.

III. OUTDOOR LIGHTING DESIGN

- A. Any luminaire emitting *more than* 1800 lumens (with 1,700 lumens being the typical output of a 100-watt incandescent bulb) shall be fully shielded so as to produce no light above a horizontal plane through the lowest direct light-emitting part of the luminaire. (Such fixtures usually are labeled Dark-Sky Certified or Compliant.)
- B. Any luminaire with a lamp or lamps rated at a total of *more than* 1800 lumens, and all flood or spot lights with a lamp or lamps rated at a total of *more than* 900 lumens, shall be mounted at a height equal to or less than the value $3 + (D/3)$ where D is the distance in feet to the nearest property boundary. The maximum height of the luminaire shall not exceed 20 feet.

- C. Any luminaire with a lamp or lamps rated at 1800 lumens *or less*, and all flood or spot lights with a lamp or lamps rated at 900 lumens *or less*, may be used without restriction to light distribution or mounting height, except that, to prevent light trespass, if any flood or spot light is aimed, directed or focused so as to cause direct light from the luminaire to be directed toward residential buildings on adjacent or nearby land, or to create glare perceptible to pedestrians or persons operating motor vehicles on public ways, the luminaire shall be redirected, or its light output reduced or shielded, as necessary to eliminate such conditions. [**Note:** This exempts most residential front-door lights, but not so-called yard-blaster wide-area flood lighting.]
- D. Any luminaire used to illuminate a public area such as a street or walkway shall utilize an energy efficient lamp such as a low pressure sodium lamp, high pressure sodium lamp or metal halide lamp. Mercury vapor lamps shall not be used due to their inefficiency and high operating costs and toxic mercury content. [**Optional:** New or replacement installation of mercury vapor lighting shall not be permitted after the effective date of this ordinance, and the public shall be encouraged to remove and safely dispose of existing mercury vapor bulbs as soon as practicable.] [**Note:** Compact fluorescent lamps are not yet commercially available for roadway or wide-area lighting.]
- E. Luminaires used in public areas such as roadway lighting, parking lots and for exterior building illumination shall be designed to provide the minimum illumination recommended by the IESNA in the most current edition of the IESNA Lighting Handbook.
- F. To protect light-sensitive wildlife habitats such as Pine Barrens, artificial lighting in or on the periphery of areas identified as such by the NH Fish and Game Department shall be minimized and fully shielded to prevent any emission above a horizontal plane through the lowest light-emitting part of a luminaire.
- G. Whenever practicable, outdoor lighting installations shall include timers, dimmers, and/or motion-sensors to reduce overall energy consumption and eliminate unneeded lighting, particularly after 11 p.m.
- H. Moving, fluttering, blinking, or flashing, neon or tubular lights or signs shall not be permitted, except as temporary seasonal holiday decorations. Signs may be illuminated only by continuous direct white light with illumination confined to the area of the sign and directed downward. [**Note:** A requirement for direct white light would prohibit internally-lit signs, which are inherently impossible to shield.]
- I. Luminaires mounted on a gas station canopy shall be recessed in the ceiling of the canopy so that the lens cover is recessed or mounted flush with the ceiling of the canopy and fully shielded. Luminaires shall not be mounted on the sides or top of the canopy, and the sides or fascia of the canopy shall not be illuminated.

IV. EXEMPTIONS

- A.** Luminaires used for public-roadway illumination may be installed at a maximum height of 25 feet and may be positioned at that height up to the edge of any bordering property.
- B.** All temporary emergency lighting needed by the police, fire or other emergency services, as well as all vehicular luminaires, shall be exempt from the requirements of this ordinance.
- C.** All hazard warning luminaires required by federal regulatory agencies are exempt from the requirements of this article, except that all such luminaires used must be red and must be shown to be as close as possible to the federally required minimum lumen output requirement for the specific task.
- D.** Luminaires used primarily for signal illumination may be mounted at any height required to ensure roadway safety, regardless of lumen rating.
- E.** Seasonal holiday lighting and illumination of the American and State flags shall be exempt from the requirements of this ordinance, providing that such lighting does not produce glare on roadways and neighboring residential properties.
- F.** Installations existing prior to the enactment of this ordinance are exempt from its requirements. However, any changes to an existing lighting system, fixture replacements, or any grandfathered lighting system that is moved, must meet these standards.

V. TEMPORARY LIGHTING

- A.** Any temporary outdoor lighting for construction or other purposes that conforms to the requirements of this article shall be allowed. Non-conforming temporary outdoor lighting may be permitted by the planning board after considering:
 - 1. The public and/or private benefits that will result from the temporary lighting.
 - 2. Any annoyance or safety problems that may result from the use of the temporary lighting.
 - 3. The duration of the temporary non-conforming lighting.

VI. PUBLIC AREA AND ROADWAY LIGHTING

Installation of any new public area or roadway lighting fixtures other than for traffic control shall be permitted only by decision of the planning board, following a duly noticed public hearing.

References

Illuminating Engineering Society of North America (IESNA)
www.iesna.org The IESNA's documents RP-33-99, "Lighting for Exterior Environments" and G-1-03, "Guideline for Security Lighting for People, Property and Public Spaces" may be particularly useful for local communities.

NH Office of Energy and Planning, Technical Bulletin 16, Outdoor Lighting, Summer 2001; re-issued 2007. <http://www.nh.gov/oep/resource/library/TechnicalBulletins.htm>

New England Light Pollution Advisory Committee (NELPAG)
<http://nelpag.harvee.org/references>

International Dark Sky Association (IDA), an organization centered in Tucson, Ariz., dedicated to preserving visibility of the night sky. <http://www.darksky.org/>

GoogleEarth "Earth City Lights" images. www.earth.google.com
To view any location at night, go to GoogleEarth menu and click on Gallery/NASA/Earth City Lights.

New Hampshire Municipal Regulations:

- Town of Raymond Site Plan Review Regulations
http://www.raymond-nh.com/html/planning_community_developme.html
- Town of Ossipee Site Plan Review Regulations
<http://www.ossipee.org/boards/planningboard/index.html>
- City of Rochester Zoning Ordinance
http://www.rochesternh.net/Public_Documents/RochesterNH_ZoningOrds/ZoningOrdinance/
- City of Rochester Site Plan Review Regulations
http://www.rochesternh.net/Public_Documents/RochesterNH_BComm/planning
- Town of Peterborough Zoning Ordinance

http://www.townofpeterborough.com/index.asp?Type=B_BASIC&SEC={331647AF-3FE3-42F9-8480-56D13558C870}&DE={53845267-5C24-4944-82D4-DCD33227CC60}

- Town of Chichester Zoning Ordinance
http://www.chichesternh.org/Public_Documents/ChichesterNH_WebDocs/forms
- Town of Wilton Zoning Ordinance
<http://www.ci.wilton.nh.us/>
- Town of Shelburne Zoning Ordinance
<http://www.shelburneh.com/Zoning.html>

NH Office of Energy and Planning List of New Hampshire Towns with Outdoor Lighting Regulations (not necessarily pertaining to dark skies) as of 25 January 2007.

Municipality	County	RPC	Outdoor Lighting
Bedford	Hillsborough	SHNPC	Yes
Bethlehem	Grafton	NCC	Yes
Brookline	Hillsborough	NRPC	Yes
Chester	Rockingham	SNHPC	Yes
Chichester	Merrimack	CNHRPC	Yes
Conway	Carroll	NCC	Yes
Dover	Strafford	SRPC	Yes
Easton	Grafton	NCC	Yes
Goffstown	Hillsborough	SNHPC	Yes
Gorham	Coos	NCC	Yes
Goshen	Sullivan	UVLSRPC	Yes
Greenland	Rockingham	RPC	Yes
Hanover	Grafton	UVLSRPC	Yes
Hopkinton	Merrimack	CNHRPC	Yes
Jackson	Carroll	NCC	Yes
Lincoln	Grafton	NCC	Yes
Londonderry	Rockingham	SNHPC	Yes
Nashua	Hillsborough	NRPC	Yes
New Boston	Hillsborough	SNHPC	Yes

New Hampton	Belknap	LRPC	Yes
Newbury	Merrimack	UVLSRPC	Yes
Newmarket	Rockingham	SRPC	Yes
Newport	Sullivan	UVLSRPC	Yes
Nottingham	Rockingham	SRPC	Yes
Peterborough	Hillsborough	SwRPC	Yes
Raymond	Rockingham	SNHPC	Yes
Rochester	Strafford	SRPC	Yes
Shelburne	Coos	NCC	Yes
Waterville	Grafton	NCC	Yes
Wilton	Hillsborough	NRPC	Yes