

Lighting for Improved Night Sky Quality

Opportunity for Cooperative Effort to Maintain the Night Sky

Abstract

The night sky is an important resource that is of key importance for visitors and locals. More of our children -- and their children -- should be able to look up at night the Milky Way. We all need good outdoor nighttime lighting for visibility and safety. It is recognized that certain lights in the Bryce Canyon area impact the night sky view and are not energy efficient. A number of alternatives and resources are available to help us keep our dark sky. Choosing the proper lighting fixtures can minimize light pollution and many times saves money. One of the best resources is a free energy audit from a variety of sources. Remember that not all energy audits take into account the dark sky issue. Cross reference with sources that have information on dark sky friendly fixtures and lamps.

It is timely that we look at this issue now. As the Bryce Canyon area continues to grow in population and development in private, commercial and government's levels, our night sky resource will be impacted. It is with cooperation and good information that we can have the lighting needed, yet save our night sky.

May 1998

Juli Ames-Curtis

Funded by the Bryce Canyon Natural History Association

Why do we need dark skies?

Have you ever walked outside on a clear dark night and been in awe of the seemingly thousands of stars? Did you ever wonder “How many stars can I really see?” On a perfectly clear, very dark night you can see as many as 1,500 stars! We are extremely fortunate in the Bryce Canyon area to realistically see that many stars on one of those magical dark nights.

Most Americans are growing up unable to enjoy what we in the Bryce Canyon area so often take for granted. They see night sky only in pictures or at planetariums. Many children (and adults) have never seen the Milky Way because of the light pollution or “sky glow” (Light Pollution Fact Sheet Appendix 1) present in all cities, suburbs, and a growing number of rural areas. *Those children and adults come to the Bryce Canyon area and are excited to see the Milky Way and many other stars.*

Satellite imagery (Appendix 2) reveals the Bryce Canyon area has one of the darkest night skies in the United States. Visitors come from all over the world to view the breathtaking scenery in the Bryce Canyon area. They expect clear, unpolluted skies, day or night, as an integral part of their experience (Appendix 3). *One of the most valuable views in the Bryce Canyon area is the naturally clear night sky!* We all have a stake in preserving this pristine area for ourselves and the visitors that we serve.

Although we now have good night sky visibility, new development in the area is a threat to this pristine environment. As more and more visitor services are built, more lighting is used. The night sky is a valuable resource that is of key importance to the Bryce Canyon area and is being impacted by additional artificial lights.

Effective and Efficient Nighttime Lighting is Necessary for Safety.

Outdoor lighting is used to illuminate roadways, walkways, parking lots, signs, work sites and buildings. It provides us with better visibility and a sense of safety. When well designed and properly installed, outdoor lighting can be, and is, very useful in improving visibility and safety. At the same time it can have a minimum impact on our night sky, while saving on energy and operating costs.

What is Good Lighting?

Good lighting does its intended job well and with minimum or **no adverse impact to the Bryce Canyon area night sky values**. Good lighting has four distinct characteristics:

1. **It provides adequate light for the intended task, but never over-lights.**

Brighter is not always better, so try to choose lights that will meet your needs without illuminating the night sky. If you can't decide what to do, consulting a good lighting designer is usually your best bet.

2. **It uses “fully-shielded” lighting fixtures; fixtures that control the light output in order to keep the light in the intended area.**

Such fixtures have minimum glare from the light-producing source. “Fully-shielded” means that no light is emitted above the horizontal and focuses light where intended. (High light output from ill-designed fixtures is mostly wasted, poorly lighting the ground, but still capable of causing a great deal of glare. Of course, all the light going directly up is totally wasted.)

Consider an angle of 0 degree as directed straight down to the ground. An angle of 90 degrees is therefore sideways, parallel to the ground, and an angle of 180 degrees is straight up. Light emitted at an angle greater than 90 degrees is uplight, and is a cause of light pollution (sky glow). Light emitted at angles between 70 degrees and 90 degrees does very little in illuminating the ground, for it would not strike the ground for a long distance from the source, and it is so faint by then that its effect in illumination is nil. However, it produces a great deal of glare—direct light striking the eye and dazzling or blinding the viewer. Glare is always bad; it never helps vision.

3. **It has the lighting fixtures carefully installed to maximize their effectiveness on the targeted property and minimize their adverse impact beyond the property borders.**

Positioning of fixtures is very important. Even well shielded fixtures on tall placed poles at a property boundary can cast a lot of light onto neighboring properties. This “light trespass” greatly reduces and invades privacy, and is difficult to resolve after the installation is complete.

Fixtures should be positioned to give adequate uniformity of the illuminated area. A few bright fixtures (or ones that are too low to the ground) can often create bright “hot spots” that make the less-lit areas in-between seem dark. This may create a safety problem. When lighting signs, position the lights above and in front of the sign, and keep the light restricted to the sign area; overlit signs are actually harder to read. Buildings ought to be similarly lit in a way to offer an attractive, safe environment without overkill.

4. **It uses fixtures with high-efficiency lamp, while still considering the color and quality as essential design criteria.**

High-efficiency lamps used for lighting not only save energy - which is good for a cleaner environment - but reduce operating costs. Most high efficiency lamps have a long life span, reducing costly maintenance. Highly efficient fixtures usually cost more initially, but the payback time is very short, as such fixtures use less energy.

Balancing against high-efficiency, though, is the quality of the light emitted. In some

applications, the yellow light cast by low-pressure (LPS) or high-pressure (HPS) sodium lamps may not be as desirable as a less-efficient, but much whiter, compact-fluorescent, metal-halide, or even incandescent light source. In other application, color is not of importance, and LPS or HPS lamps do a very good job at very low cost. Well-designed shielded lights can usually be lower in wattage, saving even more energy and money. They will light an area better than un-shielded lights of higher output, because they make use of all the light rather than wasting some (or much) of it.

How do I know a good lighting fixture when I see one?

There are many good lighting fixtures and lamps on the market today that are feasible alternatives for a night sky friendly, energy efficient lighting source (see Appendix 4). The following are suggestions that increase light on the ground (where it is needed) and save energy:

- Use a low wattage (18, 35 or 55 watt) Low-Pressure Sodium fixture, as a wall pack or with other mounting. There is lots of light, little or no glare, and no sharp, deep shadows. These fixtures offer excellent visibility. To get the desired results, "full cut off" fixtures that emit no up-going light, or "sharp cut off" fixtures may be required. "Sharp cut off" fixtures provide very good beam control and are used when some up-lighting is needed such as a nighttime golf driving range.
- Use an infrared sensor spotlight fixture. The spotlights only come on when the sensor detects movement. This type fixture is a great security lighting system: cost effective and quality lighting.
- Use one or more low wattage compact fluorescent lamps in well-shielded fixtures. The light level is adequate, and you save a great deal of energy.
- Retrofit existing Mercury Vapor fixtures with a shield such as the Hubbell Skycap. Field measurements using the Hubbell Skycap have demonstrated that 47 percent more light falls on the ground within a 100 foot radius around the fixture, which had a mounting height of 25 feet. (Appendix 5)
- Modify other existing fixtures with shields and/or aim at a different angle as to shine the light on the ground. (Appendix 6)

Light pollution and energy savings go hand in hand. The efficient and effective use of electrical lighting outdoors can offer major energy and cost savings. New, much improved light sources are now available which provide considerable more light per unit of energy. Most modern efficient lighting fixtures will also direct the light toward the ground to the appropriate area that needs to be lit for security measures. Replacement of older fixtures and lamps with newer, improved models can greatly improve efficiency.

Example of Cost Comparison: Assume that a well designed fixture is being used in these cases, so that the light output by the lamp is not wasted by an inefficient fixture. A bad fixture could be wasting more than 50 percent of the lamp's light. Lamp efficiency is measured in lumens per watt. A lumen is a unit for measuring the amount of light; a watt is a unit for measuring the amount of electrical energy used. The lamp that produces the most lumens per watt is the most efficient lamp. Compare a 175 watt Mercury Vapor (these are generally found in poor fixtures!) to 100-watt High Pressure Sodium (HPS) and a 55-watt Low Pressure Sodium (LPS) lamp. All of these lamps are outputting about 8000 lumens, quite a lot of light. Wattage's such as these, are commonly be used for residential street lighting. We assume 4100 burning hours per year, from dusk to dawn, and \$.055 (Garkane commercial rate) cost per kilowatt-hour (KWH) of use. The total wattage of the system includes the wattage used by the lamp and the ballast together. It is easy to see the potential saving gained with efficient lamps. For example, the same 55-watt LPS lamp saves \$28.92 per year on operating costs compared to a new 175-watt mercury vapor lamp.

Lamp type	Lamp Wattage	Total Wattage	KWH Use/year	Operation \$/Year
Mercury Vapor	175	208	853	46.92
HPS	100	130	533	29.32
LPS	55	80	328	18.00

Type of Lamp	Lumens per watt	Average Lamp Life (hours)
Incandescent	8 - 25	1000 - 2000
Mercury Vapor	13 - 48	12000 - 24000
Metal Halide	60 - 100	10000 - 150000
High Pressure Sodium	45 - 110	12000 - 24000
Low Pressure Sodium	80 - 180	10000 - 18000

The 175 Watt Mercury Vapor Fixture Conversion

A good example of where considerable improvements can be made is the 175-watt mercury vapor fixture. This inexpensive (\$29.95 or less, usually) old-fashioned fixture, used mostly as "dusk-to-dawn" lighting, is seen everywhere, and is particularly common as a "security" or "safety" light. Much of the light emitted comes out of the mercury vapor fixture at angles where it is of no use in illuminating the ground or the area where light is needed (see Appendix 7).

Another factor with mercury lamps is the lumen depreciation of the lamp. In five years or so the light output is decreased by a factor of two. Another five years, it is decreased by another factor of two. MVP lamp never really burns out; it just gets fainter and fainter, using the same amount of wattage to produce less light.

Easy Solutions for Good Lighting:

- Use the right amount of light, not overkill.
- Shield the light so that it goes down, not up or sideways.
- Use light timer controls whenever possible.
- Use LPS fixtures whenever possible because it is the most energy efficient and because its light can be filtered out with telescope filters.
- Avoid using round globe lights unless they are properly shielded.
- Be aware of quality lighting. Let people know when you see good and attractive lighting arrangements.
- Educate other people about the adverse effects of inappropriate lighting.

It has been the observation of the author that throughout the plateau many lights remain on all night or during the off season. Some of these lights would be perfect candidates for motion sensors and/or timers. Also, consideration could be given as to what lighting is not needed during the slower months of November through mid-April.

Energy Audits

An energy audit is a service that is provided to alert your business as to where you could save money on utility bills. Programs and organizations are available to help with new projects and existing lighting. Several will conduct free energy/lighting audits (see Appendix 8). It is important to cross reference with the energy audits and International Dark-Sky Association's Information Sheet Number 122 (Appendix 4), as not all energy efficient lighting also addresses the night sky issue.

Summary

Careful consideration must be given to any lighting project in the Bryce Canyon area in order to protect the view of the night sky. With good lighting choices we can protect our unpolluted night sky and provide for security, safety and energy efficiency.

Appendices

1. Appendix 1 Light Pollution Fact sheet
2. Appendix 2: Satellite view of the USA at night
3. Appendix 3 Important Values of Bryce Canyon NP
4. Appendix 4 Examples of Good and Bad Lighting Fixtures
5. Appendix 5 NEMA Head Fixtures, Hubbell Lighting's Skycap
6. Appendix 6 Modifying Existing Fixtures
7. Appendix 7 NEMA Fixture with and without Skycap
8. Appendix 8 Sources for energy audits

Energy Audit Sources

1. Thomas Lighting Representatives
Layton Sales Agency
1365 South Industrial Road
Salt Lake City, UT 84104
801-973-8100, FAX 801-973-8141
2. Manager, Green Lights Program
US, EPA Atmospheric Pollution Prevention Division
401 M Street SW, (6202J)
Washington, DC 20460
202-233-9190
3. State of Utah, DNR
Office of Energy and Resource Planning
1594 West North Temple, Suite 3610
Salt Lake City, UT 84114-6480
801-538-5428
4. Mark Case
Conserve-A-Watt Lighting
3590 West 1820 South
Salt Lake City, UT 84104
801-975-9363
5. Garkane Power Association, Inc.
PO Box 790
Richfield, UT 84701
800-747-5403

Bibliography

International Dark Sky Association, Tucson, AZ, Information sheets #3, 1989; #18, 1990; #30, 1990; #34, 1990; #52, 1992.

IAEEL, Ames, IA, Bringing Back the Stars, newsletter 2/96.

Prairie Astronomy Club, Lincoln NE, Light Pollution Fact Sheet

Appendices

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PAC

LIGHT POLLUTION FACT SHEET

Our goal is to encourage quality lighting! We are NOT against night lighting. The 100 inch diameter telescope at Mt. Wilson Observatory, which overlooks the Los Angeles basin, is only 11% as effective as when it was built. This telescope is severely limited in its research capabilities because of light pollution. 1 billion dollars (\$1,000,000,000) is wasted each year in the United States by lighting up the sky. This wasted light serves no purpose for safety, security or utility.....it is simply wasted energy! We want to start NOW to preserve as best as we can the sky above Holmes Park and Hyde Observatory.

Components of light pollution include:

1. Light trespass - Spill light coming from another property.
2. Glare - From seeing the bright filament of an unshielded light, troublesome and dangerous.
3. Clutter - Excessive grouping of lights, causes confusion as well.
4. Energy waste - Costing us over One Billion Dollars a year in the U.S.A. alone.
5. Urban sky glow - Domes of light over cities. Blocks out faint objects such as the Milky Way, Nebula and distant galaxies. Only a few bright stars can be seen from the city.

SOME TYPES OF LIGHT FIXTURES:

Low Pressure Sodium (LPS) fixture produces a yellow tint.

High Pressure Sodium (HPS) fixture produces a pink tint.

Mercury Vapor fixture produces a blue/white tint.

Incandescent light (bulbs) produces a yellow/white tint.

The first three types are a gas discharge source. The light is produced when the electric current passes through a container of gas, causing the energized gas to give off characteristic bands of color.

In an incandescent source a thin wire is heated to a high temperature by an electric current. This filament begins to glow and gives off light of many colors. A large amount of energy is given off as heat making the incandescent source not as efficient as the discharge source.

55 watt LPS = 100 watt HPS = 175 watt Mercury Vapor = 400 watt incandescent

For less energy a 55 watt LPS fixture can produce the same amount of lumens (light output) as the 100 watt HPS, the 175 watt Mercury Vapor and the 400 watt incandescent.

LIGHT TRESPASS:

Light from an unshielded fixture that is suppose to be illuminating the ground is also casting light upward. This is wasted light and wasted money. Some fixtures spill light onto other properties. This can be prevented by taking care in the placement and alignment of the light.

GLARE:

Generally speaking, if you can see a lights filament or source from a reasonable distance then the light is not well shielded.

The glare from an unshieded fixture can compromise visibility and increases the chance for accidents. Bright glare can also produce high contrast shadows. These shadows actually become cooridors of darkness that can become hiding places for potential criminals.

CLUTTER:

Excessive glare can make driving difficult and light clutter can cause distraction. For safety reasons every effort should be made to establish quality lighting on and near heavily traveled roads. Billboards and outdoor signs are designed to attract our attention. Often these are lit up with bright flashing lights. These light sources add considerably to the overall light pollution.

ENERGY WASTE:

A night time aerial view of a city reveals how much energy we waste by using unshielded lights. Any direct light sources that can be seen from above are contributing to a waste of energy and the precious resources that produce that energy.

Lincoln is fortunate to have some of the lowest electrical rates in the country. Summer rates are 6.5 cents per kilowatt-hour and winter rates are 5 cents. A national average is 8 cents. By reducing the amount of upward (wasted) light we can help to extend our overall energy pool. Since Lincoln is growing rapidly, this makes good economic sense.

URBAN SKY GLOW:

This is the bane of astronomers world-wide. The combined output of all the lights in a city cause the sky to be washed out. Faint deep sky objects such as galaxies and nebula become impossible to see.

Sky glow is rapidly becoming worse. We must start now to encourage quality lighting. Reducing the upward shining light will help eliminate these light domes. Our children need to be able to see the stars. They are the ones with the eager questions and imaginations that will shape our future!

SOME EASY SOLUTIONS:

1. Use the right amount of light, not overkill.
2. Shield the light so that it goes down, not up or sideways.
3. Use light timer controls whenever possible.
4. Use LPS fixtures whenever possible because it is the most energy efficient and because its light can be filtered out with telescope filters.
5. Avoid using round globe lights unless they are properly shielded.
6. Be aware of quality lighting. Let people know when you see some good and attractive lighting arrangements.
7. Educate other people about the adverse effects of inappropriate lighting.

Hyde Observatory Steering Committee

Erik Hubl

Supervisor

624 South 51st

Lincoln, NE 68510

(402) 488-1698

Prairie Astronomy Club

Doug Bell

3721 Timberline Ct.

Lincoln, NE 68506

(402) 489-8197

International Dark Sky Association

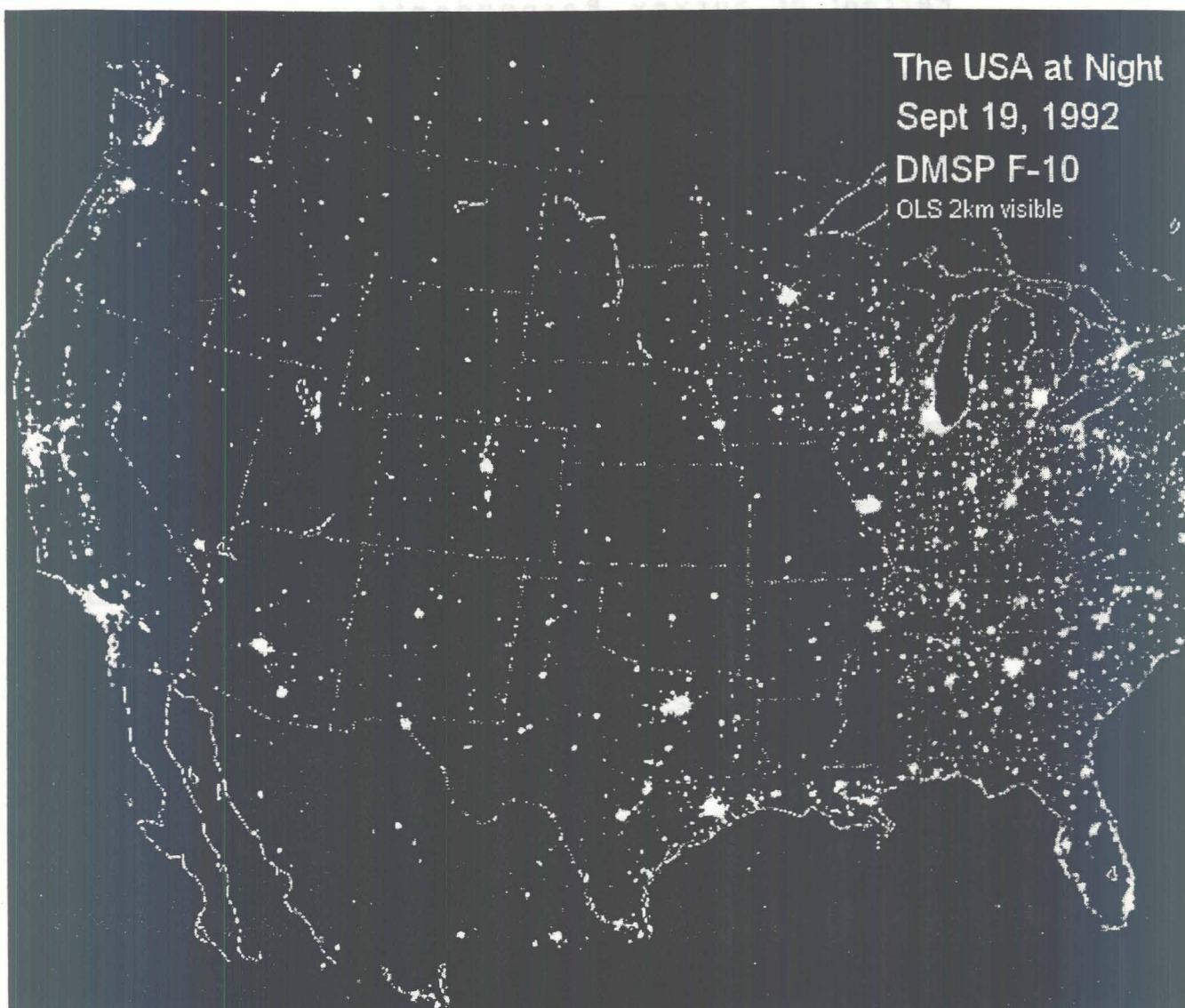
Dr. David L. Crawford

IDA's Executive Director

3545 N. Stewart

Tucson, AZ 85716

(602) 327-9331



ACE CANYON WP



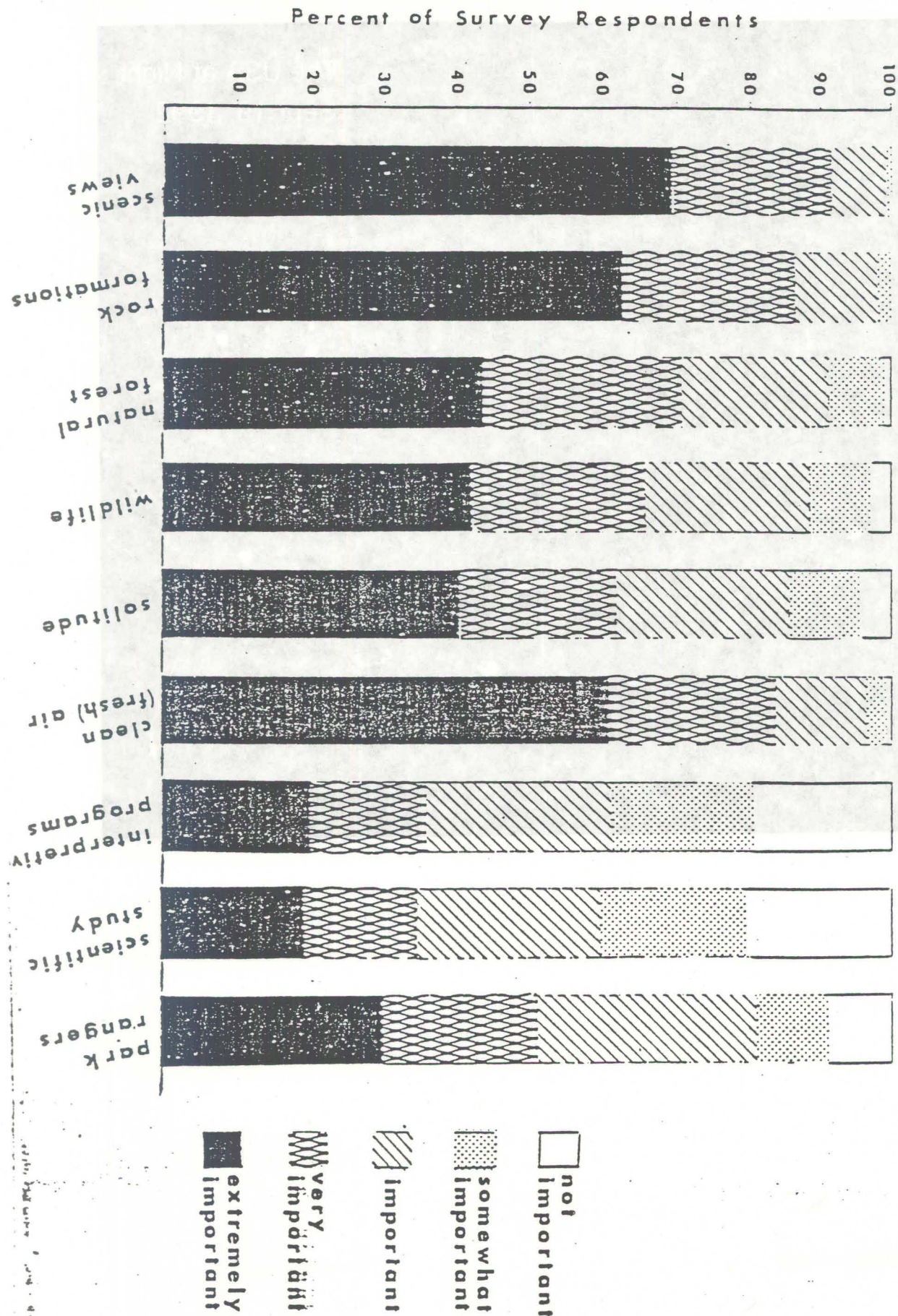


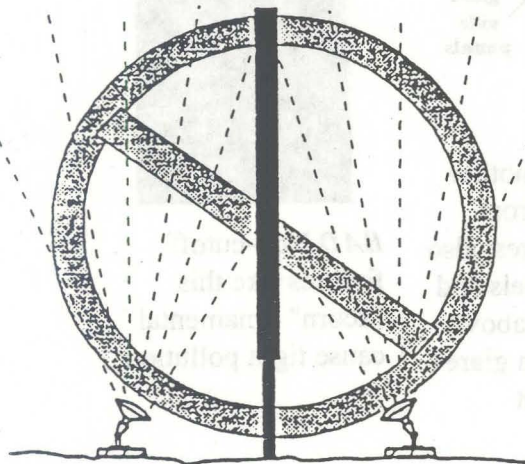
FIGURE 3. IMPORTANT VALUES OF BRYCE CANYON NP

Appendix 3

From: 1980 Visitor Survey (Kelly) USDI.

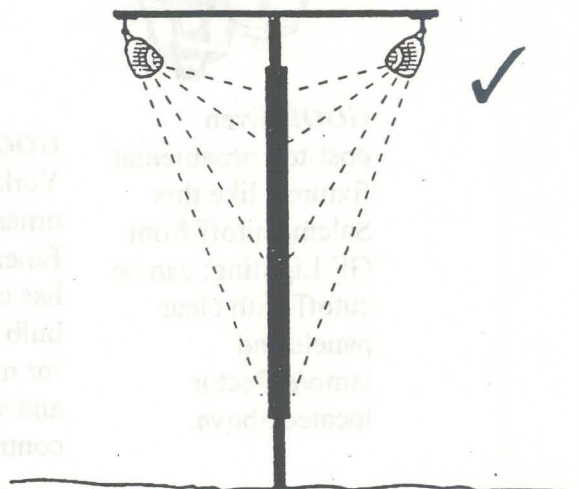
EXAMPLES OF SOME COMMON LIGHTING FIXTURES

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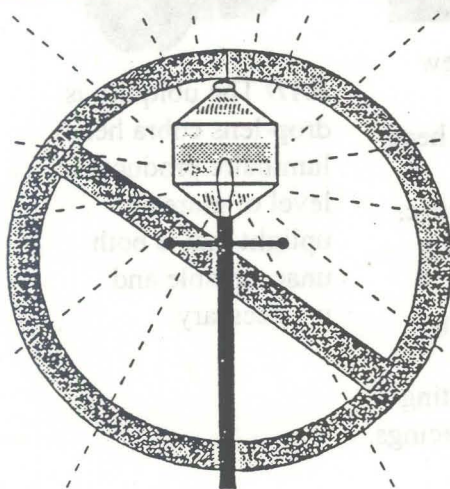


Ground-mounted
Billboard Floodlights

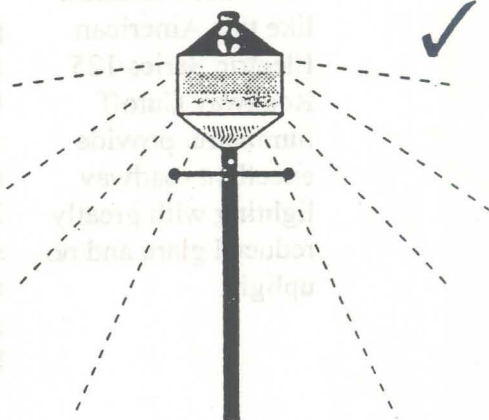
GOOD



Top-mounted
Billboard Floodlights
(carefully focused onto billboard)



Post-style Lamp
(more than 1,800 lumens)



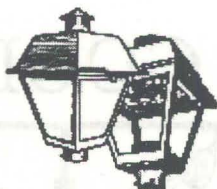
Post-style Lamp
(lamp set in opaque top)

Examples of Good and Bad Lighting Fixtures

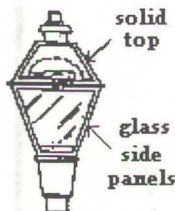
Information Sheet 122, May 1997



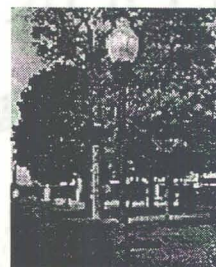
International Dark-Sky Association
3545 N. Stewart Ave., Tucson, AZ 85716 U.S.A.
E-mail: SaveOurSky@aol.com
WWW: <http://www.darksky.org>



GOOD Even post-top ornamental fixtures, like this Salem Cutoff from GE Lighting, can be cutoff with clear panels and lamp/reflector located above.



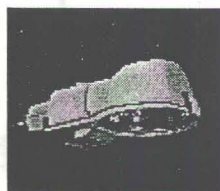
GOOD The Yorktown, another ornamental from Emery Fixtures, also has clear panels and bulb located above for maximum glare and spill light control.



BAD Non-cutoff fixtures like this "acorn" ornamental cause light pollution.



GOOD Flat-lens cobra head fixtures, like this American Electric Series 125 Roadway Cutoff luminaire, provide excellent roadway lighting with greatly reduced glare and no uplight.



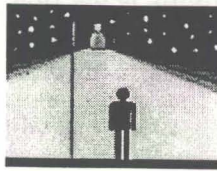
GOOD This new generation of flat-lens cobra head fixture from American Electric, call the DuraStar 2000, provides superior lighting uniformity at standard mounting heights and spacings.



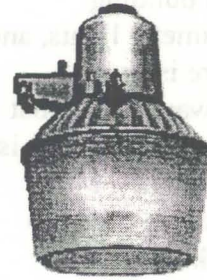
BAD The ubiquitous drop-lens cobra head luminaire produces a level of glare and uplight that is both unacceptable and unnecessary.



GOOD Many existing dusk-to-dawn security lights and residential streetlights can be retrofitted with the Hubbell Skycap.



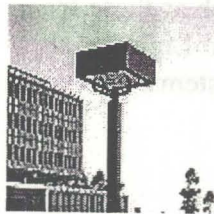
GOOD The Hubbell Skycap turns any standard NEMA head light into a full-cutoff light with wide area coverage.



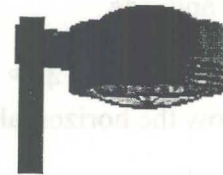
BAD NEMA head style fixtures are very inefficient, sending about 20% of the light upward and another 20% horizontally outward, creating glare.



GOOD Flat-lens shoebox fixtures come in many forms; square, rectangular, circular, etc. All control the light with internal reflectors. Glare and light trespass are minimized; no uplight is produced.



GOOD Post-top flat-lens shoebox fixtures like this one provide good area illumination without light pollution.



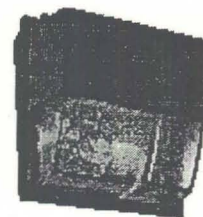
BAD (sometimes) The telltale sag lens gives this luminaire away as a possible problem. If the lens is clear and very shallow, and the bulb wattage is not too high, this type of light can cover a wider area without too much glare or uplight, but beware!



GOOD Full-cutoff wall packs such as this mcPhilben 101 Wall Sconce make excellent entryway and building



GOOD Recessed canister lights built into the eaves or

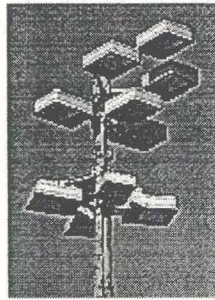


and building perimeter lights, and there is enough forward throw that adequate lighting is provided for near-building parking.



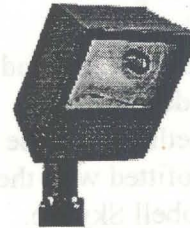
GOOD If floodlights must be used, they should always have top and side shielding, and be pointed at least 45 ° below the horizontal.

into the eaves or canopy of a house, garage, or other building is the first choice for lighting building exteriors.



GOOD Even sports lighting can be done well, if one uses cutoff light fixtures such as these from Soft Lighting Systems.

BAD Wall packs like this should never be used. They produce enormous glare and uplight.



BAD Unshielded floodlights provide a trashy "prison yard" look and should not be used.

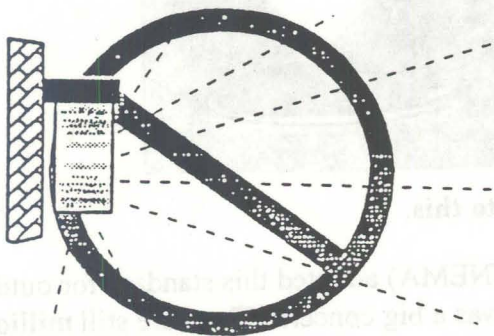
GOOD Floodlights should be shielded and angled down to prevent glare and uplight. The light should be pointed at least 45 degrees below the horizontal. Floodlights should be shielded and angled down to prevent glare and uplight. The light should be pointed at least 45 degrees below the horizontal.



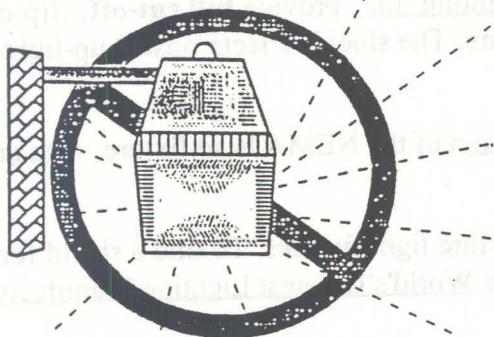
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EXAMPLES OF SOME COMMON LIGHTING FIXTURES

POOR



Typical "Wall Pack"

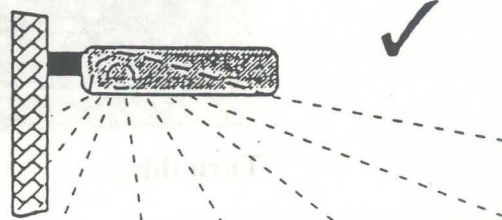


Typical "Yard Light"

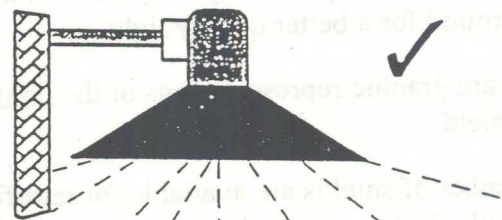


Area Flood Light

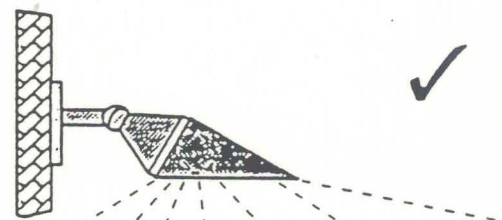
GOOD



Typical "Shoe Box" (forward throw)

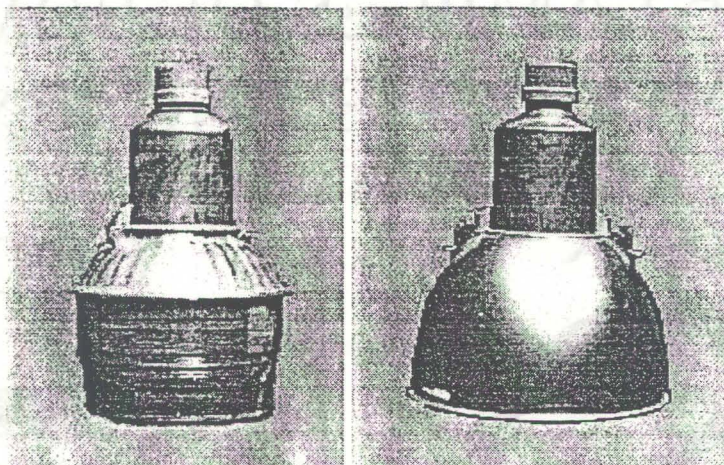


Opaque Reflector (lamp inside)



Area Flood Light with Hood

NEMA Head Fixtures



Turn this...

Into this.

The National Electrical Manufacturers Association (NEMA) adopted this standard for outdoor area lights back in the 1960's, before conserving energy was a big concern. There are still **millions** of these fixtures in use in the United States.

Today, several manufacturers, including Hubbell Lighting, Inc., provide **full cut-off**, clip-on shields to replace the refractor originally used with this fixture. The shield reflects wasted up-light back to the ground for a better quality light.

Here are graphic representations of the light distribution of the NEMA head fixture, with and without the shield.

A number of shields are available for retrofitting existing light fixtures. To find a shield for a particular light, contact the manufacturer. Here is The World's Greatest Lighting Manufacturer List.

Hubbell Lighting's Skycap

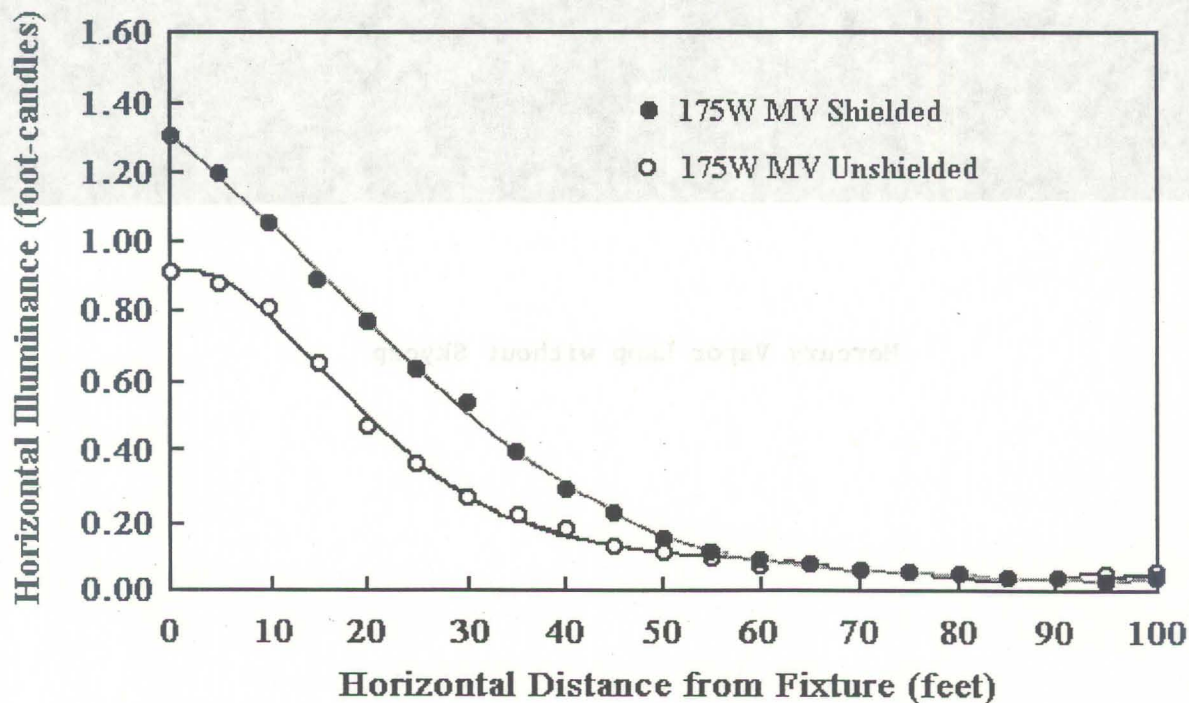
David Oesper of Outdoor Lighting Associates, Inc. has provided some photos of the improved Skycap in action. The first image is just the reflector unit itself. The second image shows the improved Skycap attached to a 70 watt high pressure sodium (HPS) NEMA head fixture. The last two images are before and after installation in the real world. Note the dramatic reduction of glare and improved visibility. These improved units can be purchased from Outdoor Lighting Associates, Inc., 1208 Wilson Ave., Ames, Iowa 50010-5426; Phone: (515) 233-0117; Fax: (515) 233-0117; E-Mail: OutdoorLtg@aol.com. For each unit sold, \$2 is donated to the IDA.

- [The improved Skycap shield](#) (197k bytes)
- [The improved Skycap shield attached to a NEMA head fixture](#) (224k bytes)
- [70W HPS fixture before installation of an improved Skycap shield](#) (191k bytes)
- [70W HPS fixture after installation of an improved Skycap shield](#) (159k bytes)

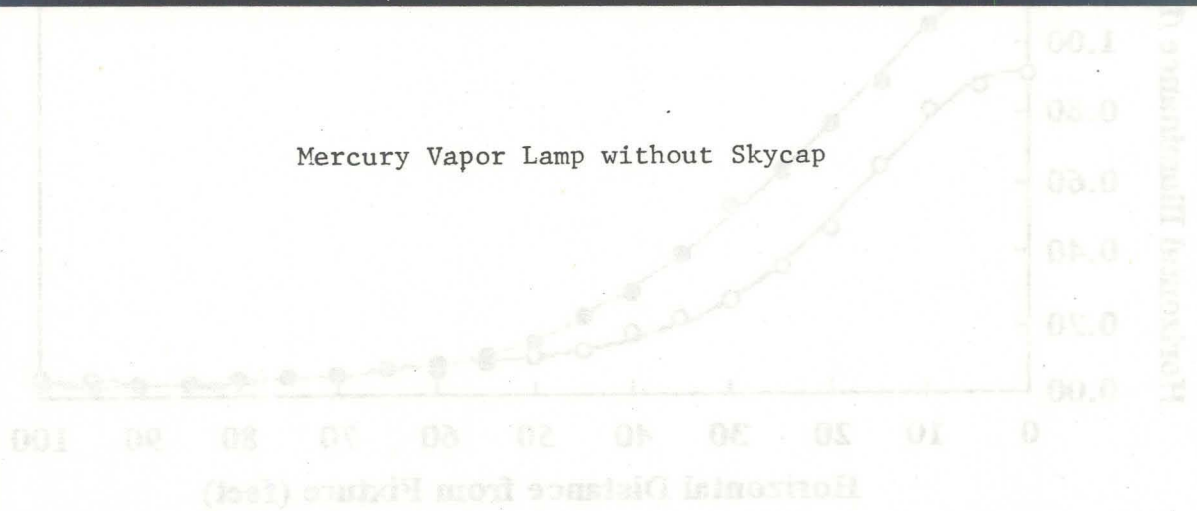
In 1994 Royce Bitzer and Dave Oesper conducted field measurements of a 175 watt mercury vapor NEMA head fixture with and without the Skycap shield. The results are given in the plot below.

Light Distribution of MV Luminaire

NEMA Type: Shielded vs. Unshielded



Hubbell Skycap Retrofit (25' mounting height) results in 47% more light on ground in the zone 0 - 100 ft.



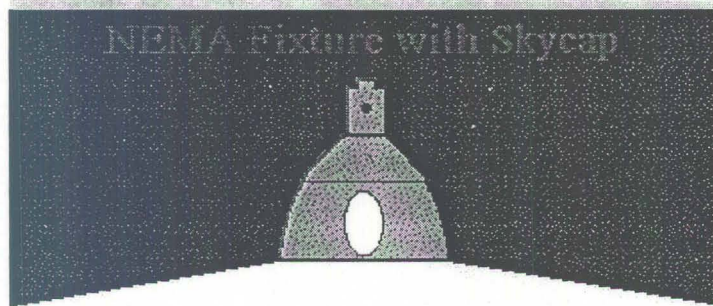
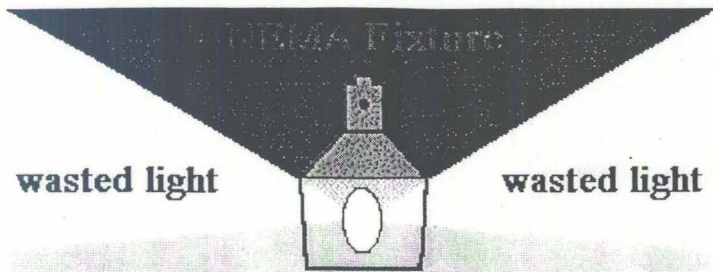


Mercury Vapor Lamp with Skycap

Most cheap fixtures have poor beam spread and poor beam control. They usually take better and more costly internal reflectors to get light out without glare and to give better light distribution. Modifying installed fixtures to reduce glare or installing more fixtures to better coverage can be expensive.

Cheap fixtures often have inefficient lamps and short lamp life, so they use far more energy than needed. Paying for more electricity than needed is expensive, as is the higher maintenance costs of these so-called "cheap" fixtures.

Some cost comparisons



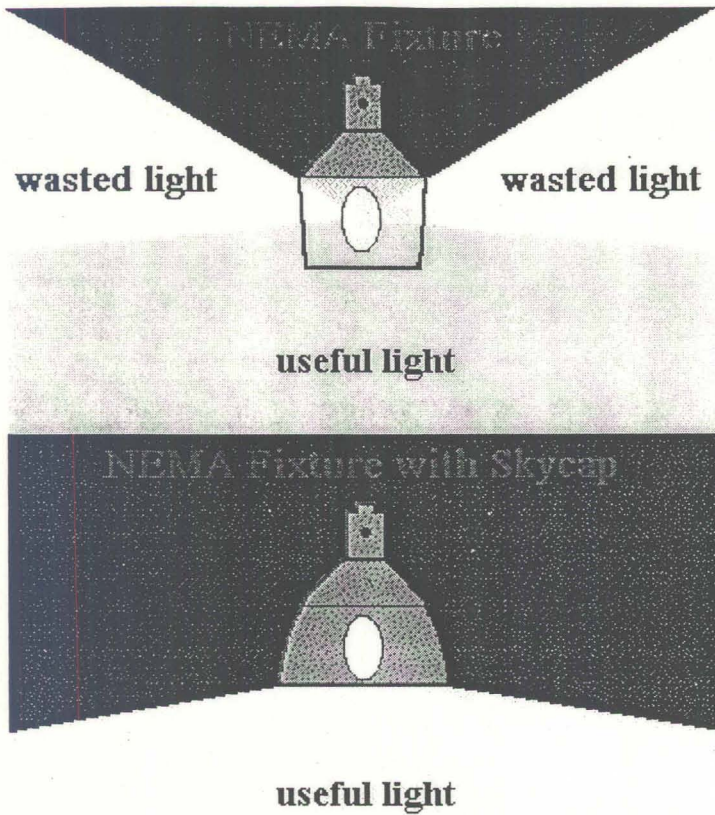
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Carlson Power Association, Inc.
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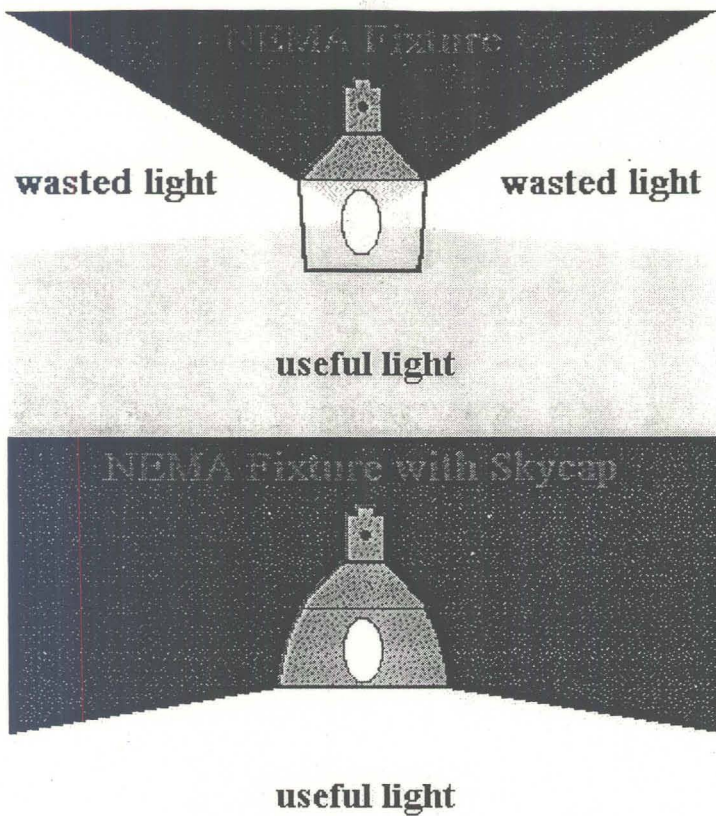
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