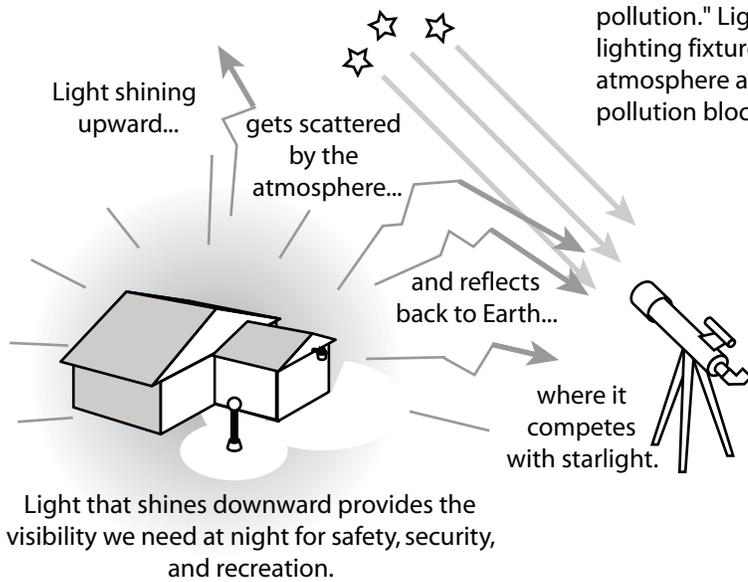
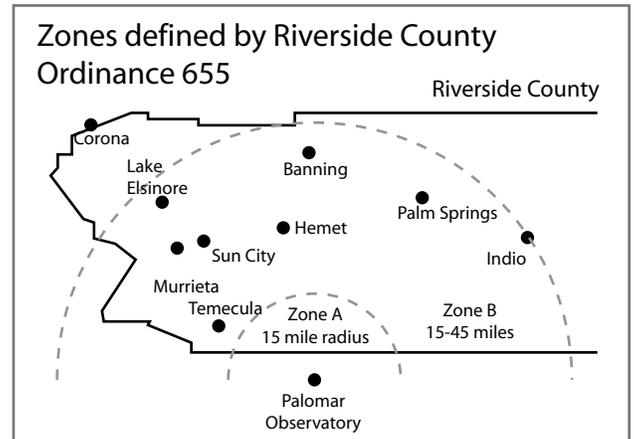


# What is light pollution?



The scientific community and lighting regulations often use the term "light pollution." Light pollution is the unused portion of light from poorly aimed lighting fixtures that shines up and sideways. This light is scattered by the atmosphere and reflected back to the ground as sky glow. This sky glow is light pollution blocking our window to the universe.



Zones defined in Riverside County ordinance 655 regulating light pollution. San Diego County has a similar ordinance.

# Why preserve our night sky?



The Milky Way photographed from a backyard in Wildomar, taken Aug. 2005.

**Preserve rural qualities**—Many of us moved away from larger cities to enjoy a more rural environment. Dark, starfilled skies are a rural quality that can be preserved by good design of outdoor lighting.

**Preserve research opportunities**—Palomar Observatory is advancing our understanding of the universe, and will continue to do so with the help of neighboring communities.

**Preserve recreational opportunities**—Local astronomy events draw hundreds of visitors per evening. We love to look at the night sky, which is a part of our heritage.

**Eliminating light pollution also eliminates bad lighting**—most light pollution is from poorly designed lights. Light pollution can be reduced merely by ensuring that our night lighting minimizes glare (a safety hazard), is energy efficient, and respects neighbors' privacy.

# What is the effect of light pollution?



A 3.5-minute exposure shows the light pollution to the north of Palomar Observatory. (Note: this exposure is longer than the Milky Way photo above. The longer exposure brings out more of the light pollution)

From a research perspective, light pollution is noise, whereas the objects being studied are the signal. Research relies on getting a good signal-to-noise ratio. Once the background noise equals or exceeds the signal, no telescope or technological innovation can separate the two. The inverse photos below show how light pollution acts as noise. The pristine sky has low noise, and therefore a high signal to noise ratio. The light polluted sky shows the same region but with the background noise resulting from light pollution.



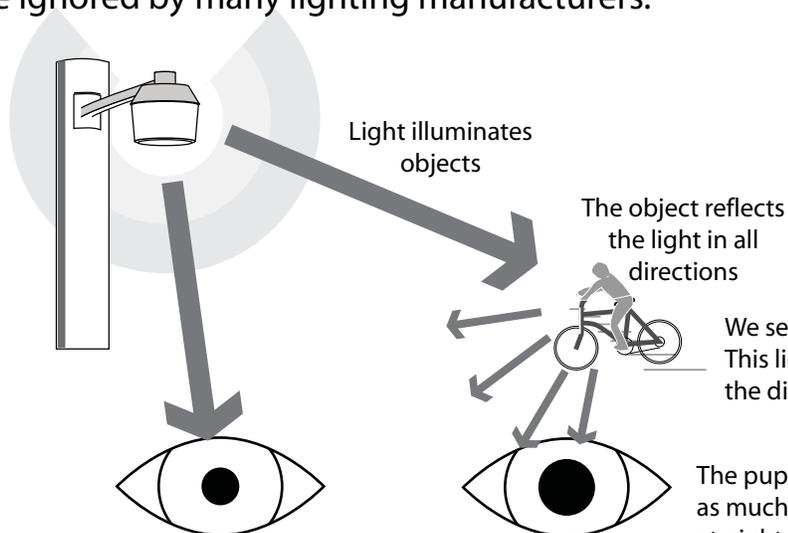
Pristine sky (reversed image, stars are black)



Light polluted sky (reversed image, stars and light pollution are black)

# Principles affecting lighting design

The human eye imposes certain design requirements that are ignored by many lighting manufacturers.



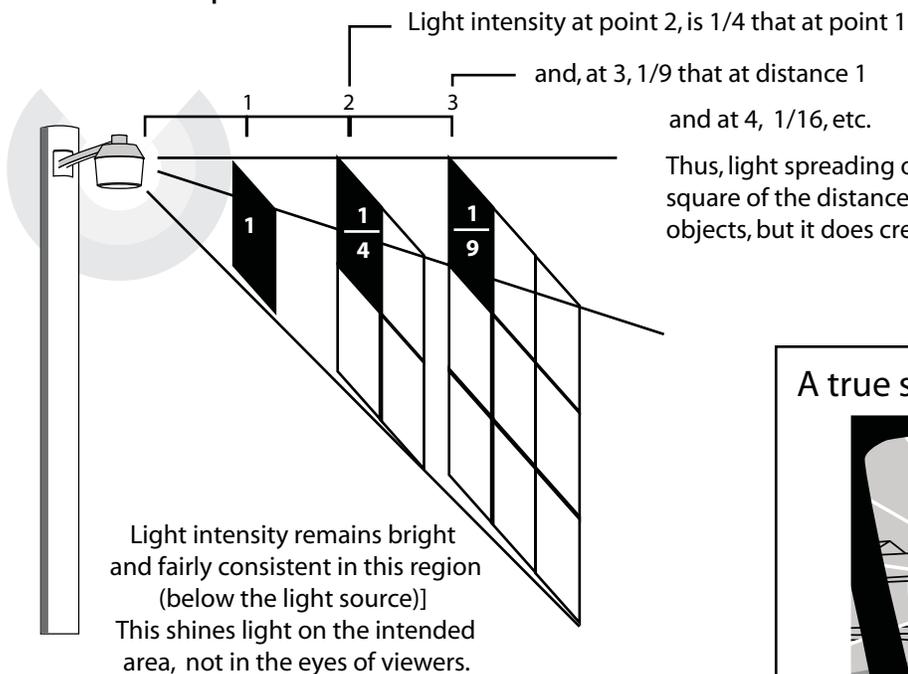
An effective light illuminates objects without directly shining into the eye of the observer. The common yard light, drawn here, sends bright light in all directions, which wastes energy and can hinder seeing. Some may consider blinding the observer (or in truder) a valuable security measure. If so, proper shielding can direct more light onto the property affecting only trespasser rather than the passers by.

However, the pupil will contract involuntarily to the brightest light source in the field of view, making seeing difficult the fainter light.

We see the light reflected from the objects. This light will always be much dimmer than the direct light from the source.

The pupil of the eye needs to open as much as possible to see objects at night.

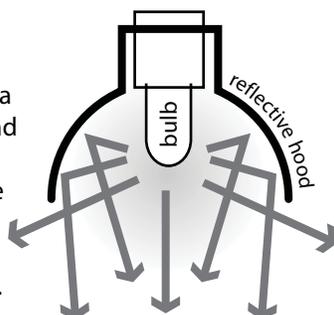
The intensity of a radial source dissipates according to an inverse square law.



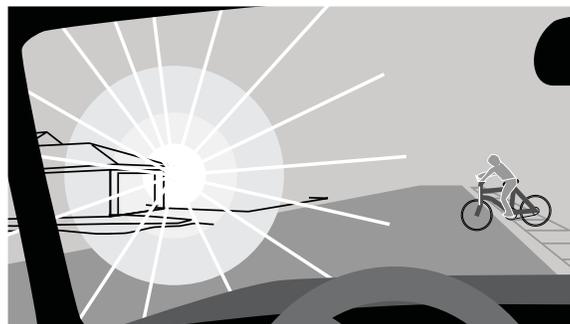
There is a limit to the distance at which a light is effective. Beyond that distance, the light only contributes glare and light pollution.

Thus, light spreading outward quickly loses intensity as the inverse square of the distance travelled. It is not useful to illuminate objects, but it does create glare and light pollution.

The only improvement on lighting intensity comes from reflective shields that focus all the light onto a target area, as seen in flashlights and headlights. Many manufacturers of yard lights make retrofit shields like the one shown here. Using such a shield puts more light onto the property with lower wattage bulbs.



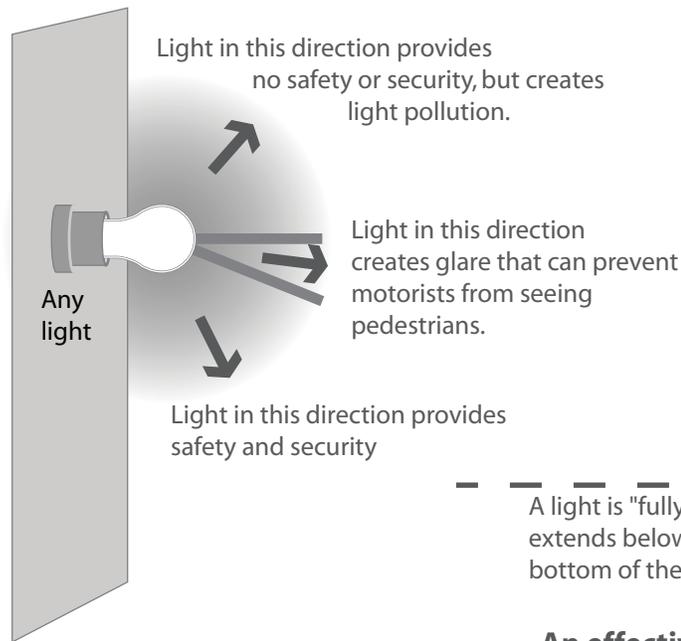
## A true story illustrates these principles



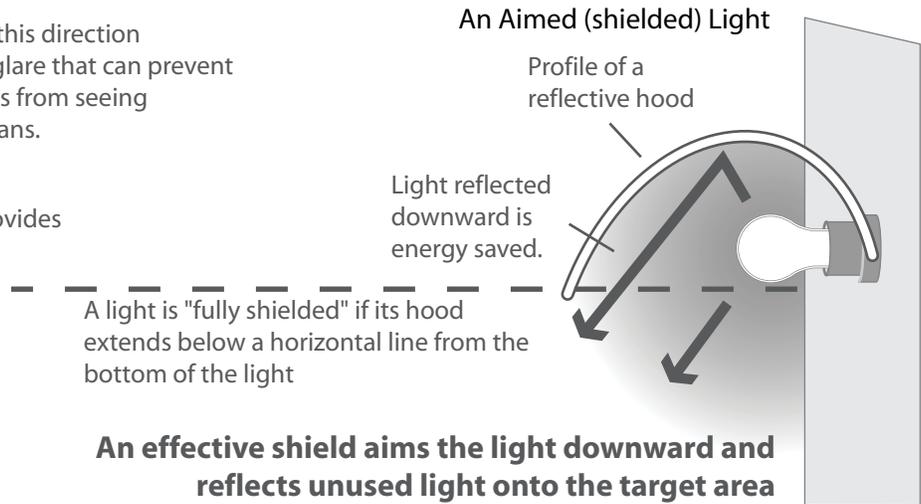
This unshielded mercury vapor light overwhelms a driver's ability to see well at night. I couldn't see a child about to enter the street on a bicycle. Fortunately, the child's parent was under the light waving to the child. I slowed and missed the child because I saw the parent's gesture, but I could not see the child until he or she was in front of my car. Using a cover that aims the light downward would preserve the safety and security function while eliminating the glare hazard as well as the light pollution. John Garrett

# Application of lighting principles

## Shielding Outdoor Lights



Outdoor lighting is most effective when shielded:  
 A light with an aimed, reflective hood saves energy.  
 Shielding reduces or eliminates glare, which improves seeing at night.  
 Shielded lights do not send unused, wasted light upward and outward where it becomes light pollution.



## Why Low-Pressure Sodium Lights have minimal impact on the observatory

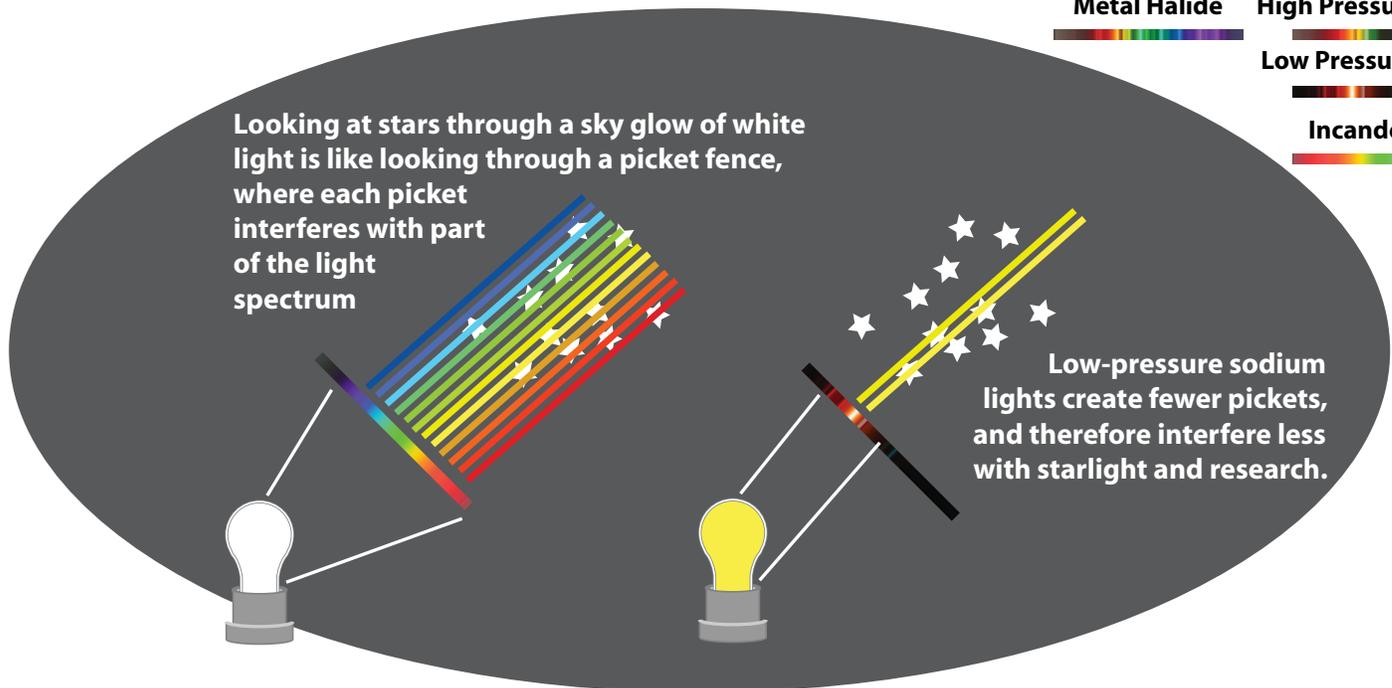
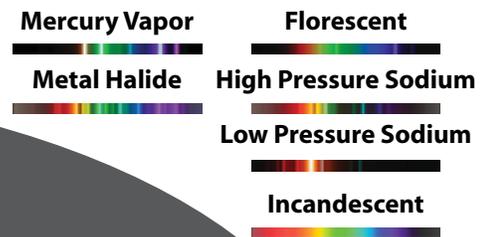
Light consists of wavelengths which correspond to the colors we see.

A white light produces wavelengths across the full visible spectrum:

But low-pressure sodium lights produce wavelengths in a narrow band:

In addition to direct upward lighting from unshield fixtures, some light pollution is created when light reflects off of surfaces such as roadways, buildings, and parking lots. Using low pressure sodium lamps in these applications allows Palomar Observatory to continue research despite the inevitable light pollution from these sources.

## Light spectra of various lamp types



# Crime and lighting

Lighting is a common response to crime. However, the fear of crime should not allow complacency in the quality of lighting, because the link between lighting and crime is tenuous, and if lighting is a deterrent, then good lighting that minimizes light pollution and glare, and saves energy, should be just as effective.



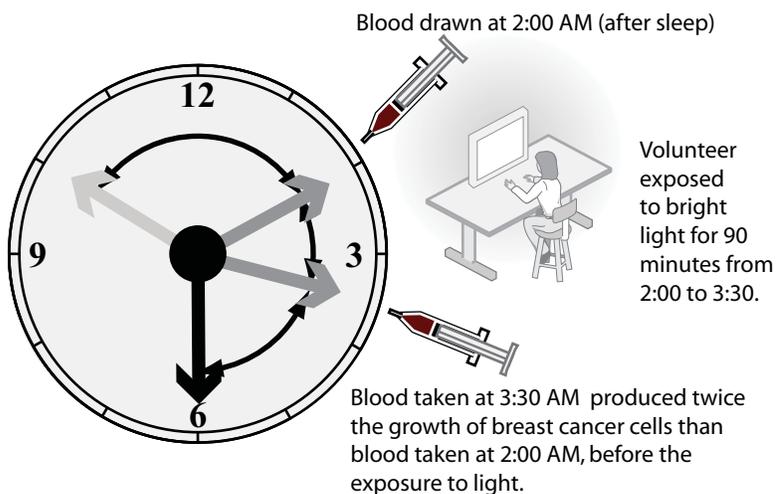
One night's incident of vandalism illustrates that we can find any example of crime with light or lack of light to support what we already believe. If we believe light deters crime, then example A should catch our attention: graffiti sprawled in the cover of darkness. Example B shows another side of the building where light is present; the paint suggests previous incidents. Example C shows the complete range of this act of vandalism: graffiti sprawled under a gasoline canopy, one of the most brightly lit places in any community.

## Health: Lighting and Cancer

Science News (1/7/06) reports on experiments establishing a link between night lighting and cancer.

The article reports that breast cancer rates are increasing where there are increases in night lighting. An examination of a database of nurses' health revealed higher breast cancer rates among night shift workers. The proposed mechanism is that light reduces the brain's production of the body's cancer fighting chemical melatonin. Melatonin is produced by the pineal gland and is suppressed by stimulation of the optic nerve. When there is light, melatonin production is turned off; when it's dark, the pineal gland resumes production of melatonin.

The experiment exposed volunteers to bright light in the middle of their sleep. Blood was taken before and after exposure and both samples were used to promote breast cancer growth in a laboratory.



## Call for Action

The night sky is part of our common heritage, and therefore the communities in our valley should collectively participate in efforts to raise awareness and therefore perhaps reawaken interest in protecting their night skies.

Building codes and ordinances should take a proactive role in defining and implementing standards for effective and efficient safety and security lighting

Lighting should be designed to avoid light trespass. This should be built into the fixture or placement of the fixture to minimize the harm from inappropriate lamp types or wattage.

Lighting should use low-pressure sodium wherever white light is not needed.

All safety and security lighting should be directed downward through full cutoff fixtures. Flood lighting should never shine into the street where its glare poses a safety risks for motorists and pedestrians

Decorative lights that cannot be shielded should have a minimum brightness, use low pressure sodium lamps as much as possible, and have restrictions on their hours of operation.

Sign lights should be shielded with downward pointing lights. Stray light from uplit billboards should be shielded.

Citizens need some legal recourse for intrusive lighting.

Uplighting should have some guidelines: such as: Make a reasonable effort to darken the background so less uplight is needed; Constrain the light beam to illuminate only the object; Use low pressure sodium where allowable.

Indiscriminate yardlights should be phased out, e.g., perhaps as part of energy conservation programs that replace the lense with a reflective hood and lower wattage bulb.

Lighting ordinances should use sample specifications that can be fulfilled locally for various lighting tasks.