Light Pollution
Classical Argument Position Paper
Louis Scott Busby

Urban light pollution and light trespass has a drastic effect on our environment and should be regulated through implementing strong lighting ordinances. It destroys our view of the night sky and directly contributes to a decrease in some animal and plant populations. It also has a marked detrimental effect on astronomic research. I am an amateur astronomer and astrophotographer and my scientific endeavors have caused me to be increasingly sensitive to the problem of light pollution. In order to determine how best to eliminate or reduce light pollution, a little research is required to fully understand the impact of light pollution and its effects.

Light Pollution by Cestomano / © Retrieved December 5, 2008 from http://bighugelabs.com

Go outside on any clear night and try to count the stars. How many can you see? If you have ever opened an astronomy book or "surfed" the internet you have probably come across a picture of a galaxy or a nebula perhaps taken by the most famous of all space telescopes, the Hubble[1]. The Hubble Space Telescope's unprecedented views of the universe are remarkable in that they show billions upon billions of stars. For most people, it becomes difficult to understand why, on any given night and depending where they live, only a few hundred to a thousand stars are visible.

I have spent many clear nights in my driveway observing and photographing the stars and DSOs or deep space objects[2]. In my research I have found several reasons that we can only see a fraction of the stars that are actually there. One of them is the earth's atmosphere, a very dense mix of oxygen and hydrogen gases that all living things depend on in order to exist. Our atmosphere contains large amounts of stuff like water vapor that forms clouds and obscurants like dust and smoke. Carbon dioxide is also prevalent as a natural occurring gas or caused by pollution from human industrial activities and automobiles. These things when combined tend to filter out all but the brightest of stars visible to us on earth.

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Generally, our atmosphere is not necessarily poor for viewing the night sky and the particles from pollutants and water vapor don't have too much of an effect on our ability to see the stars. However, add the rampant, uncontrolled and explosive increases in night time illumination from cities, business parks and residences the effect on the atmosphere becomes significantly compounded and literally makes the stars disappear from our view.

Since the industrial revolution[3] the amount of light pollution in the atmosphere has increased a million fold since the invention of the incandescent light bulb. Advances in electrical lighting technologies occurring during the 20th century have resulted in remarkable increase in the illumination of our cities, businesses, and homes. Lighting technologies like florescent tubes, halogen and halide fixtures, sodium and mercury based lighting and other types have lighted our paths through the night. Maybe it is because of some prehistorically inherent fear of the dark or primordial need for humans to light the night in order to see what evil things lurk there.

All of this night time illumination has in essence destroyed the natural environment of our earth. It has become brighter and there is a noticeable effect on our lives, our health and the life cycles of creatures that inhabit our planet. Boyer, J. (2005) wrote in her article for the Humane Society of the United States that "Light pollution's harmful effect on wildlife has been well-documented. It disturbs the breeding cycles of animals, stunts the growth of certain flora and fauna, and in some animals, even affects the production of hormones regulating everything from fat storage to egg production."[4] These studies have shown that night migrating birds who depend on stars for navigation become disoriented by bright city lights and radio/microwave tower lights causing then to fly into obstacles causing them to be injured or killed. Sea turtle fry newly hatched from eggs buried in the sand become disoriented and rather than head toward the open ocean and the reflection of the moon, instead turn away to follow the brightly lit beachfront areas with devastating effect by reducing the numbers of the surviving population that actually make it to the sea.

Light pollution or the creation of it, causes another problem that needs addressing. Artificial lighting requires electricity that is produced by the consumption of fossil fuels. Burning of fossil fuels adds pollutants to the atmosphere by introducing particulates and greenhouse gases. This results in the increase of carbon dioxide which contributes to global warming.

So just how much energy do we consume? In April 2006 the average household in the U.S. consumed 920 kilowatt hours at a cost of 11 cents per kilowatt hour (Department of Energy) and would pay $101.2 for it based on the April 2008 average rate. If we were to consider the state of Virginia alone, total net electricity generation for Aug 2008[5] was 6,881 thousand megawatt hours. You do the math. A large portion of this electricity is used for lighting our cities, businesses, highways and residential properties. Did you know that ten 100 watt light bulbs burning for one hour equals one kilowatt hour? (1 Kilowatt = 1000 watts).

Let's look at it from another perspective. If we were to calculate the amount of energy consumption and pollution created from one 100 watt incandescent bulb burning from dusk to dawn for one year using the U.S. National average rate of electricity usage of 10.5 cents per kilo watt hour (kWh) we would arrive at the following figures[6]:

- number of hours/yr: 4170
- lamp life: 1000 hours X 4 bulbs
- operating cost $41.91
- kWh / yr: 417
- Carbon Dioxide emission: 583 pounds
- Sulphur Dioxide emissions: 7 pounds
- Nitrous Oxide emissions: 4 pounds
- Mercury released/yr: 4 ounces
- Coal used: 196 pounds
- Emission equivalent (same as driving): 475 miles
- Number of trees to null effects: 1

This is not going un-noticed especially with the high price of consumables like oil and natural gas. Minkle, J. (December 21, 2007) writes in his article *"100-watt bulb set to be dimmed permanently"*, **"….**that **c**ongress passed legislation designed to boost energy efficiency and reduce greenhouse gas emissions. The measure raises fuel-efficiency for passenger vehicles to 35 miles per gallon (mpg) by 2020, up from 25 miles mpg now (the first such increase since 1975) and phases out 100-watt incandescent light bulbs by 2012."[7] The *Los Angeles Times* reports that the 822-page bill, which passed after Democrats agreed to strip out a $21 billion tax increase to avoid a presidential veto, is expected to shave the nation's energy consumption by an estimated 7 percent and cut carbon dioxide emissions by 9 percent by 2030. (*Los Angeles Times*)

After talking at length about light pollution and its effects on earth's environment and its related energy consumption, I'll move on to another negative effect. It is one so insidious as to remain largely unknown to the general public. Simply, it is the impact that light pollution has on astronomical research. Astronomers are intensely familiar with the properties of light. We examine in great detail the light emitted from stars that are millions of light years[8] away from earth. In fact, the many objects in our universe a few million light years away offer themselves up for critical review and detailed analysis by astronomers who endeavor to answer the enduring questions about how are universe was formed and how life came to be on planet earth. Observational astronomy has led to the discovery of the planets in our solar system, asteroids, comets, nebulae in our own Milky Way[9] and other galaxies beyond our own.

Most of these objects are so far away and so faint, that they easily avoid detection with all but the most sophisticated telescopes. Stray lighting tends to illuminate the sky causing skyglow which obliterates these faint objects. That is why astronomers require the darkest and clearest of skies with minimal or non-existent light pollution. Generally, astronomers build their observatories and

research telescopes on the tops of remote mountains or far away desert locations to escape the star dimming effect of earth's atmosphere and the light pollution from our cities.

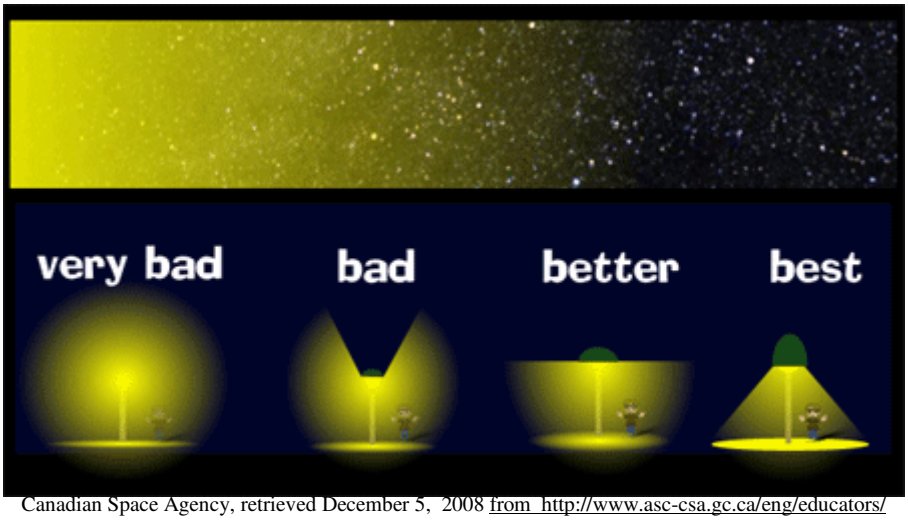
The Andromeda Galaxy, photo by Louis Scott Busby

Star brightness and the brightness of DSOs are measured in terms of magnitude. On the magnitude scale the brightest stars seen from earth are usually 1st magnitude or brighter. Dimmer stars are measured in degrees using larger numbers. In other words, the magnitude scale is interpreted as 1st magnitude stars being the brightest while dimmer stars are measured at ever decreasing magnitudes of 2, 3, 4 etc. So a star or object with a magnitude of 5 would barely if at all be considered naked-eye visible. In most of our cities and towns, only 1st, 2d or 3rd magnitude stars are naked-eye visible. Most DSOs are at magnitudes of 10 or greater (dimmer). As you move out into the countryside away from bright lights, 4th and 5th magnitude stars become apparent to naked-eye observers. This is a practical demonstration of the impact of light pollution. Every light source from your next door neighbor's porch light to the parking lot illumination from the mall a few miles away, has a distinct effect on our ability to see the stars. I suggest you do a little experiment. Go outside on a clear, moonless night and look at the stars from your backyard. Make a mental note of how many stars you can see. Then go to your local mall and stand in the parking lot at night and look at the stars once again. How many can you see now? Chances are you may only see a handful of the brightest 1st and 2d magnitudes stars or perhaps a bright planet. The reason for this of course is the light pollution caused by the lights that illuminate the parking lot. So, if I want to observe or photograph the very faint DSOs, I must travel some distance from the city lights to see these objects in a telescope.

The types of lighting are important to consider as well. Street lighting and security lighting are the most prevalent of all lighting and are the main cause of light pollution. Not only are they extremely bright, but they have a tendency to illuminate wide areas including the sky above them. Sodium and

mercury vapor lamps also create light within certain wavelengths. These are the very wavelengths that are emitted from DSOs and the effect of this type of light actually absorbs the light from DSOs making them more difficult to see even with telescopes.

It's not very likely that the preponderance of humanity will give up their night time illumination. However, there are still some things that can be done to gradually rid ourselves of some of the annoyances caused by light pollution. Several counties in the state of Virginia have already enacted lighting ordinances that restrict wasteful lighting. Most lighting ordinances identify the most bothersome types of lighting and limit them in numbers, maximum wattage output, spectrum, height above the ground, timed illumination and horizontal emission. These ordinances usually call for "full cutoff"[10] lighting that prevents light expansion beyond the areas intended to be lit. There are specifications for this kind of lighting as described in an article written by Douglas Palin (2001), *"Full Cut-Off Lighting: The Benefits"* for www.IESNA.org. "The UW-Madison-Arboretum, McKay Visitor Center outdoor lighting demonstration project, sponsored by the University of Wisconsin and Madison Gas and Electric (MG&E), also showed the advantages of using full-cutoff light fixtures. Five of the McKay Center's six parking and security lights were retrofitted by MG&E with Hubbell Skycap© full cutoff shields. Measurements taken before and after the retrofit showed a doubling of illumination under the Skycaps, with no increase in power consumption. In addition, one unshielded 150w high pressure sodium fixture was replaced with a shielded 100w fixture, resulting in a 30% reduction in electric power use, with no reduction in illumination. In all cases, the Skycaps eliminated upward and outward glare. The effect of full cutoff lighting is shown in the graphic below"[11].



Canadian Space Agency, retrieved December 5, 2008 from http://www.asc-csa.gc.ca/eng/educators/

When discussing the issue of light pollution, there is a certain degree of apathy from most people. No one wants their liberties infringed upon by hearing that someone wants them to limit there night time lighting, turn off their porch light or turn off their security lighting. I

completely understand that most people consider night time illumination as a deterrent to criminal activity and a safety consideration. I certainly wouldn't want someone to become a victim of crime nor would I want someone to get hurt. However, street lighting has no measurable effect on the number of auto accidents and criminals will continue to commit crimes at night regardless of security lighting. In fact, a Department of Justice report[12] concludes that "there is no documented correlation between the level of lighting and the level of crime in an area." And contrary to popular belief, "more crimes occur in broad daylight than at night." The study suggests that "increased night time lighting reduces the fear of crime, not the crime itself."

At this writing numerous activities by several organizations, primarily the International Dark Sky Association, have instituted awareness and educational programs that highlight the issue of increased light pollution. Together these organizations have raised the issue to a level that has resulted in actions by communities and cities to control and restrict wasteful and detrimental night time lighting.

Hundreds of Astronomy clubs have also instituted programs that increase public awareness and show how to reduce the overall impact of light pollution. As for your help, it is quite simple, reduce light pollution by following a few simple rules: Don't leave outdoor lighting burning throughout the night -- turn exterior lights off between the hours of 10pm and 5am, reduce output of outdoor security lights and porch lights by using lower wattage bulbs -- I recommend 40 watt bulbs for porch lights and 100 watt lamps for flood lights, shield outdoor flood lights so they illuminate the ground beneath them and not a large area around them, put driveway flood lights on a timer or use motion sensor lights so they shut off automatically, eliminate lighting that illuminates the entire front of your house, remove, turnoff, or shield pole mounted security lights on your property, and refrain from installing new unshielded outdoor lighting. By taking these easy steps, together we can reduce unwanted and unwarranted light pollution and enjoy the wonderful night sky and the splendor of the universe as nature intended.

North America at Night[13]

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Bibliography

[1] Named after the trailblazing astronomer Edwin P. Hubble (1889-1953), the Hubble Space Telescope (HST) is a large, space-based observatory which has revolutionized astronomy by providing unprecedented deep and clear views of the Universe, ranging from our own solar system to extremely remote fledgling galaxies forming not long after the Big Bang 13.7 billion years ago.

[2] Deep Space Objects or DSOs are what astronomers use as a term to describe the many galaxies, nebulae and star clusters that can be viewed through telescopes.

[3] Wikipedia. *Industrial Revolution*. Retrieved on November 28, 2008, from http://en.wikipedia.org/wiki/Industrial_Revolution.
"The Industrial Revolution was a period in the late 18th and early 19th centuries when major changes in agriculture, manufacturing, production, and transportation had a profound effect on the socioeconomic and cultural conditions in Britain. The changes subsequently spread throughout Europe, North America, and eventually the world. The onset of the Industrial Revolution marked a major turning point in human society; almost every aspect of daily life was eventually influenced in some way."

[4] Boyer, J. (2005). *Let There be (Less) Light.* Retrieved on 28 November 2008 from, http://www.hsus.org/press_and_publications/humane_society_magazines_and_newsletters/wild_neighbors_news/volume-7-number-1-winter-2005/let_there_be_less_light.html

[5] Department of Energy *Table 1.6.A. Net Generation by State by Sector, August 2008 and 2007* Retrieved 28 November 2008 from,
http://www.eia.doe.gov/cneaf/electricity/epm/epmxlfile1_6_a.xls

[6]Sources / Notes

- CO_2 released per kWh used: 1.397 lb/kWh from http://www.americanforests.org/resources/ccc/assumptions.php
- SO_2 released per kWh used: 0.01582 lb/kWh from icole.home.att.net/
- NO_x released per kWh used: 0.00965 lb/kWh from icole.home.att.net/
- Mercury (Hg) released per kWh used: 0.0006 lb/kWh from icole.home.att.net/
- CO_2 from coal/oil/natural gas: 35.8/42.6/21.7 % from www.iaea.org/inisnkm/nkm/aws/eedrb/data/US.html
- Miles driven equivalents: 1.22666 mi/kWh @ 20 MPG from www.fueleconomy.gov
- Trees required: 0.00225 trees/kWh from http://www.americanforests.org/resources/ccc/assumptions.php
- Lamp data (wattage, lumens, life, etc.) from product packaging, bulbs.com, and manufacturer web sites.
- *(Totals might not match due to decimal rounding errors)*

[7] Minkle, J (2007). "News Bytes of the Week—Bell tolls for 100-watt light bulb." *Scientific American.* Retrieved 28 November 2008 from, http://www.sciam.com/article.cfm?id=news-byte-100-watt-light-bulb

[8] A light-year is a unit of distance. It is the distance that light can travel in one year. Light moves at a velocity of about 300,000 kilometers (km) each second. So in one year, it can travel about 10 trillion km. More precisely, one light-year is equal to 9,500,000,000,000 kilometers.

[9] The Milky Way is the galaxy which is the home of our Solar System together with at least 200 billion other stars (more recent estimates have given numbers around 400 billion).

[10] The term "cut-off" first entered the lighting vocabulary in 1937, as a way to describe a "shielding reflector" for street lighting. Palin, D. (2001). *Full Cutoff Lighting: The Benefits.* Retrieved 2 December 2008 from http://www.iesna.org/PDF/FullCutoffLighting.pdf

[11] Liebl, D.S., Sanford, D.P. (April 2000). *Full Cutoff Lighting Demonstration Project*. Retrieved on 2 December 2008 from http://darkskywisconsin.uwex.edu/about/publications/Cutoff%20Demonstration.pdf

[12] Tien, J. M., Odonell, V. F., Barnett, A. I., & Mirchandani, P. B. (1977). *U.S. Department of Justice Study of Street Lighting and Crime.* International Dark Sky Association - Information Sheet 63. Retrieved 2 December 2008 from http://data.nextrionet.com/site/idsa/is063.pdf

[13] Photo: North America at Night, Defense Meteorological Satellite Photo (DMSP)
Source: International *Dark Sky Association (IDA) Satellite imagery* © IDA. Retrieved 2, December 2008 from http://www.pha.jhu.edu/~atolea/second/page1.html

The author at Westmoreland State Park, VA, 2008