

A night photograph of a lake with buildings and trees illuminated by artificial lights, with a bright light source visible in the sky.

Can Artificial Outdoor Lighting Harm the Environment?

**Robert Dick
2008**

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Robert Dick, June 19, 2008



When we think of a prosperous city, we usually conjure up images like the one above. When we think of the view from a rural cottage we dream about scenes like this:



The image showing the Rideau Lake was taken several decades ago, and cannot be taken again. The best and the worst of the city have come to the country.

Common in these images are trees, water (actually ice) and the differences are: buildings and stars, lights shining from empty buildings, and a 1million people huddled indoors with at least one observer trying to enjoy the sky.



The stars are still there, but the glare from outdoor lights prevent our eyes from adapting to the darkness that would otherwise allow us to see the stars.

We have a word to describe our respect and protection of our environment: Stewardship. We all share in this responsibility. It is not just up to the federal, provincial or local governments. It

is up to all governments and individuals. But we are still trying to understand what it means to be a good steward. In some cases it means we must change our past assumptions about how we treat the environment. We now accept the fact that we share it with all life forms and we are no longer free to do what we want.

Sure, we can see the lights but can this light actually affect nature?

Bugs, Birds, Fish, Mammals, Plants and Humans



We will start with the ecology of the night and how it affects biology. This is a new branch of science called scotobiology – the study of biology’s need for darkness.

Animals are not so different from humans as we may think. We are all bio-chemical machines subject to the ebb and flow of hormones. Our chemistry is based on DNA that controls the production of enzymes that in turn produce proteins that are the chemical machines that make our physical bodies work. For ethical reasons, we choose to limit our experimentation on humans.

However, we have been unwittingly subjecting humans to illumination experiments for more than a century. What we are now finding from plant and animal studies is very disturbing!

Bugs



chain.

There are water bugs and bugs in the air and they are both affected by light pollution. One of the lowest orders of water life is zooplankton. They feed on algae that need light to provide energy to metabolize minerals in the water. Some zooplanktons avoid light – and so they remain deep during the day and surfaces to feed on the algae at night. With artificial shoreline lighting, the plankton stay deep throughout the night and the algae remain on the surface. This separation can lead to the concentration of algae on the surface (algae bloom) and it weakens the aquatic food

We see and feel the air bugs! As much of a nuisance as we feel they may be; a healthy bug population is critical to the ecosystem. Some insects fly to light. This distraction draws them away from their otherwise normal behaviour: feeding, procreating, pollinating and migrating. They are mesmerized by the light and fly about it until they overheat or fall out of exhaustion.

Birds



Most songbirds are insect eaters. Without the insects, many birds will migrate to other areas where insects are more plentiful. We have recorded declining bird populations in urbanized areas and have concluded that this is due to the disruption of their habitat. A single light can draw insects from about 100 meters away – wider than a house lot. If each house has a door light, an entire city block may discourage insect populations and the corresponding bird and animal populations.

Fish



Some fish seem to be immune to light, while others are not. Light can draw fish to the surface for harvesting in aquaculture but some fish seem to be driven deeper. The affect of nocturnal lighting on fish depends on the light intensity, colour, water depth, temperature and degree of maturity of the fish. This is complex indeed. Until more studies are done, we just don't know the extent of the impact of artificial lighting on the various species of fish that

we find in our lakes and rivers. However as with human medicine, we should always error on the side of “doing no harm”. We are just now learning that shoreline lighting IS doing harm, so it is important that we step back from this trend of lighting up our shorelines.

Plants



Plants also have complex reactions to light. Some plants seem to like over illumination, while others do not. The science of scotobiology is so new; there have been few focused efforts on understanding how much plants need a dark night. The long-term effects are not yet known.

There are some warning signs however. Like other life forms, plants deduce the seasons from the amount of dark time (night). An otherwise long night (typical of autumn or spring) but with a short interruption of bright light is interpreted as two short nights (characteristic of summer). This can cause a delay in releasing their leaves for winter, flowering too early for the pollinating insects, or to delay until it is too late to build up of reserves for winter.

Mammals



Many mammals are nocturnal but have adapted their behaviour to the cycle of the moon's phases. Over a month the Moon brightens after the new moon and fades after the full moon. Animals are vulnerable to predation during the bright times, so they limit their foraging close to home and carry food back home instead of eating it in the field. This significantly decreases their nutrient intake. Away from artificially lighting, they can recover by foraging during the dark time. Under light pollution – there is no dark time. The animals will either slowly starve, or move on to other areas.

However, this puts pressure on the surrounding habitats, as it must support more foraging animals.

Animals separated from their normal foraging grounds by an illuminated road cannot see field beyond the lights. Even the occasional passing car can temporarily blind them with headlights. Their natural instinct is to wait until they can see where they are going. This can leave them in the open and vulnerable to predation. This may again cause them to abandon their established foraging patterns for new ones, which will impact other species as they compete for resources in another area.



This foraging pressure may upset the balance and even lead to ecological collapse. One dusk-to-dawn or unshielded streetlight will cast shadows up to a kilometre away and can contaminate several square kilometres of countryside.

The contaminated area will not be without wildlife. But those who remain will be more aggressive and tenacious such as racoons and other scrounging animals.

Humans



Nocturnal lighting affects humans as well but we tend to dismiss it as a product of our prosperity – as we did in the 1960s with increasing air and water pollution and urban noise. However, all Earth-based animals – humans included - have evolved to accommodate the 24-hour rotation of the Earth and our day / night cycle.

Daytime activity results in physical damage (skin, muscle and other tissues). We need rest for our body to repair itself. But we can't rest while we are busy hunting and avoiding predators. Our "downtime" is after dark and our bodies enforce this repair period but putting us to sleep. Our bodies know when it is time to sleep because it is dark. For our bodies to be "shutdown" the hormone melatonin is released into our blood to slow down our metabolism, lower our temperature, etc, so the repairs can begin.

It takes about 3 hours for most of this work to be completed - longer if we have more extensive damage. The best time for these repairs is in the early part of the night. Before we went to bed, my grandmother use to say that the hours before midnight were the most beneficial. She seems to have been right.

The scheduling of the release and purging of the melatonin and other hormones is governed by our internal body clock – the circadian rhythm. It is kept in sync with our daylight activity by detecting the day/night contrast in lighting. By reducing this contrast, our circadian rhythm begins to shift out of phase with our needed rest period.

Our minds also require a bit of a clean up. Think of your desk at work at the end of a very busy day. Papers and notes are scattered about. These have to be organized and filed so they can be easily found the next day. Without this re-organization – we would have a very confused work world. It is the same with our minds. Our daily memories have to be compressed and filed so they can be quickly recalled when needed.

Without a clear day-night contrast our bodies become confused about when to shutdown. We do not sleep well unless it is dark. After several hours of shallow sleep our body concludes the night is over and flushes these hormones from our blood. Our bodies do not

undergo a full repair cycle. In the morning we feel tired, grumpy and our minds are unfocused during the day.

“But I feel fine”, we say. Really? Remember how much better you feel after a good night’s sleep? In modern times, we rarely sleep well and some of this seems to be due insufficient repair time. Unfortunately, some of us even augment the exterior light pollution with an indoor night-light!

“Are there more physical drawbacks with artificial lighting?”

Remember the illuminated shoreline? From the human stand point; bright lights along the shoreline make it very difficult to navigate the channel. Glare from unshielded shore lighting prevents our eyes from becoming adapted to the darkness. At night, a boater will only be able to see the points of light long the shore rendering the channel markers and channel hazards very difficult to see. Clearly, glare along the shoreline results in a safety hazard that should be removed.

How about the insects? We have all seen moths flying around a light. We have also found in the morning the ground or floor under a bright light covered with dead flies. As we now know, these are not just a nuisance we must clean up. Turning off the lights and closing curtains at the end of a business day is an easy, cost effective way of solving this problem. It also increases the privacy of your workplace.

How dark is a dark enough?



We don’t really know. But, our species has evolved to tolerate the lunar cycle. So as a guess, it may be the level of the full moon.

Is the light of the full moon a practical limit? Not today, and probably not tomorrow. But we can start today to slowly wean ourselves off our cultural desire for excessive artificial lighting. It is unwise to demand a revolution. But it is well within our ability to reduce artificial lighting, save electricity and infrastructure costs in lighting systems and reduce the pollution that comes from power generation.

Why do we have such a fixation on outdoor lighting – even after bedtime?



We have seen it and perhaps done it. It is late, we turn on our outdoor light and go to bed. Perhaps we are scared of the dark! We should not dismiss this reason too quickly. Humans are diurnal creatures. We live for the daylight. Some predators at night could hurt us. Yet our eyesight has evolved to be remarkably sensitive to low light levels – so we can avoid a sabre tooth tiger!

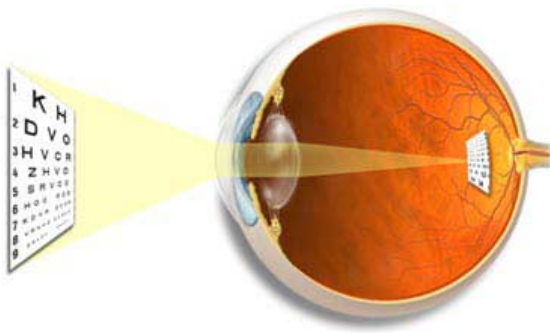
Our sensitivity to light covers 10^{14} or 100 trillion times (www.yorku.ca/eye/thejoy.htm). We can detect the light of a billion-billion-billionth of a Christmas tree light bulb! We can read a newspaper under the light of a full moon. (Well, I can). And we can even read the small print in a legal document in a small urban parking lot at 3 am – if this happens to be important to you!

Bright lights have become the symbol of a prosperous society in the same way that in the past prosperity has been symbolized by air and water pollution and we use to pride ourselves over our control of nature. These have been shown to be unwise. We are only just starting to understand what stewardship means and what we must give up if we are to take our responsibility seriously.

Can bright light blind us?

We are told that light is good. It can help us wake up in the morning. It helps us see at night. But can there be too much light? To answer this, we must understand the design life of our bodies! The human eye undergoes changes after it reaches its 40-year – our “design life”.

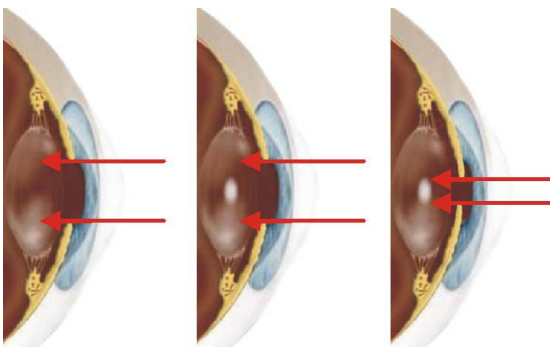
We should first discuss how our eyes work. Light enters our eye through the cornea. From there the lens focuses the light onto rear surface (the retina) where tens of millions of cells absorb the light. Each retina cell contains molecules that are split by the energy of the light.



This begins the transfer of electrical signals to the brain where they are interpreted as an image.

There are two different types of retina cells. Those in the centre give us our astounding ability to read the fine print of a legal document and distinguish colours. Those in the periphery, allow us to see starlight at night but they are colour blind.

If the outdoor scene is too bright, the light molecule can be completely broken down and it takes time for it to form again. We are blind! (A camera’s bright flash leaves a blind spot that may take a few minutes to recover.)



So as not to flood our retina with too much light, our brain controls our iris – between the cornea and the lens. If the brain detects too much light it can close it down. Generally during the day this “window” into our eye (the pupil) is only a few millimetres in diameter. At night it can be 6 to 8 mm across.

As we age, insipient cataracts begin to form naturally in the centre of our lens. Normally, this would not cause a problem. For most of us Cataracts do not progress far enough to affect

our daytime vision, but what about at night?

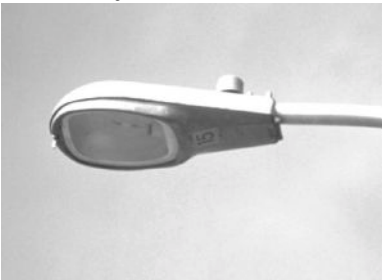
When there is a bright glaring light, our iris closes down to protect our eyes. Great! But the light that does enter our eye passes through only the centre of our lens and through the incipient cataract resulting in a foggy image. During the day, there is plenty of light for our brain to make out details in the periphery of our vision. But at night most of the scene will be dark and the light scattered by the cataract will reduce contrast and visibility.

Paradoxically, senior citizens will see less with bright glare at night than with lower illumination levels with no glare. And with the “greying” of society, this is a problem we must address today. The new lights we install now will be around for 30 years.

Practical Solutions

With the extensive and grave consequences of outdoor lighting, you must be feeling that the remedies will be disruptive and expensive. This is where my mood changes, because the solutions are easy, inexpensive and don't require great social or cultural change. Unlike air and water pollution, reducing light pollution is a no-brainer. Why then isn't it more popular? For every volunteer like myself there are literally thousands of people paid to sell you larger and more powerful fixtures and some of them just don't know how light affects our environment.

Roadways



Lighting fixtures will last about 30 years so the trick is to start now. Adopt a plan to use only full cut-off (FCO) fixtures and replace old fixtures as part of your regular infrastructure renewal, or as units fail.

Roadway lighting should only illuminate the road and not shine through the windows of adjacent homes. So, again, we should use FCO fixtures. To prevent a brilliant island of light in the midst of a dark road – reduce the illumination levels to a respectable level. The City of Ottawa has

adopted 6 lux for rural main streets (about 6 full moons) – 1/3 the level used by other cities. With low wattage lamps they can use smaller FCO fixtures.

On suburban and rural roads, marker lighting at intersections should be only 70-watt cut-off fixtures; you may now be using 100-200 watts. (Marker lights are to indicate an intersection – not illuminate it.) Car headlights are designed to do the rest – so let's use them.

Reducing light pollution from non-municipal lighting requires public understanding and support. A political decision is required. Should the environment be protected? We no longer allow sewage to be dumped into the waterways, or garbage to litter our roads. These offend our senses. Why should light pollution be different? Why should one person be allowed to affect the environment of a neighbourhood?

These forms of pollution are being corrected with public education and with their support. So, what about the life forms we jeopardize when we leave on outdoor lights – then go to

bed? This can be just as lethal for wildlife as other forms of pollution. The public should be made aware of this if we are to gain their support.



There will be those shouting “Me first” claiming the right to illuminate the sky, but these arguments should be and have been set aside in favour of the greater good.

A major source of light pollution is commercial signage that stays lit throughout the night – long after business hours and with few potential customers on the road. These lights not only produce significant glare down the road creating hazards for motorists, they put the property on display for vandals – and vandals won’t even need a flashlight to do their evil deeds.

Light does not provide security – people do. Unless someone monitors the illuminated area, there is no security. Anonymity provides more security than an unmonitored illuminated building.

Conservation Lands

What kind of lighting do we need on Conservation Lands? Most visitors arrive in daytime, so resources should be tailored for daylight hours. There may be access permitted after dark, but historically, very few people have taken advantage of this. Should we compromise the integrity of a conservation area for a few nighttime visitors? I don’t think so. In any case, these people are probably visiting the area to enjoy the night and would not want artificial lighting.

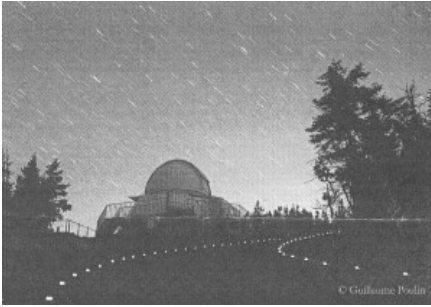
Parking lots

If the area has a defined parking lot then perhaps the manager may wish it to be illuminated. If that is the case, then very limited lighting should be installed that does not shine beyond the immediate area of the parking lot otherwise it will impact the ecology of the area. This requires illumination that is restricted to the immediate area with little or no blue light content to which wildlife is sensitive. It should be of low intensity so as not to degrade our night vision too much. A timer should turn the lights off to save electricity and the environment. The darkened parking lot may also discourage vandals.

A 70-watt HPS lamp in a full cut-off (FCO) fixture mounted at a 6-meter height is more than adequate for a 20 x 20 meter area. But to save the cost of electrification, perhaps your budget dollars might be better spent on some other project.

Pedestrian Pathways

Pedestrian paths don’t need much light. Indeed, most nightwalkers will have their own flashlights, so no active lighting is needed – or perhaps wanted! But navigation at night can still be a problem for humans. Sadly, some managers may choose to close the area because of perceived liability in the absence of expensive lighting for navigation. Or, they may light up the area but this will ruin the nocturnal environment the visitors may be seeking.

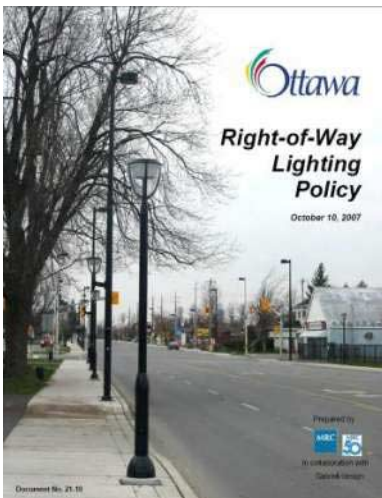


It is expensive to lay underground electrical wires to illuminate a path. A far more cost effective solution is to use phosphorescent markers (4 cm in diameter). These passive disks absorb light energy during the day then emit light throughout the night. They may be mounted on the ground or on posts (bollards) along the edges of a path. They were developed to delineate the roads and pathways around the Mont-Mégantic Observatory east of Montreal and are being considered for use by Parks Canada.

Urban Solutions

Lighting in a city is a much more political topic than lighting in a nature preserve. But most of the same principals apply. In a town or city, we need to minimize glare, avoid light trespass, and because power is expensive, reduce how much we use.

All lighting engineers have heard of the Illumination Engineering Society of North America (IESNA). Many cities light their streets to the recommended levels in their guidelines. But these levels do not reflect the new reality of very expensive energy, installation and maintenance costs and the general public aversion to the degradation of our environment. Besides, the visibility criteria are based on tests that used 20-year old university students, not the 40-plus people in today's society. The difference is significant.



What is the current wisdom in urban lighting? Calgary adopted a program to replace many of their streetlights with FCO fixtures AND reduced wattage by 30-50%. Several Canadian cities have adopted FCO fixtures as the municipal standard. And most recently, the City of Ottawa has selected a number of FCO fixtures as an economy measure to reduce the range of products in their inventory, AND the city illuminates most streets to only 50% the IESNA levels, and then illuminate only necessary roads. No longer do municipalities light for the sake of lighting and blindly adopt the high levels that were promoted during the days of cheap energy.

If large cities do this to save money, why don't smaller communities do the same thing? After all they have a much smaller tax base.

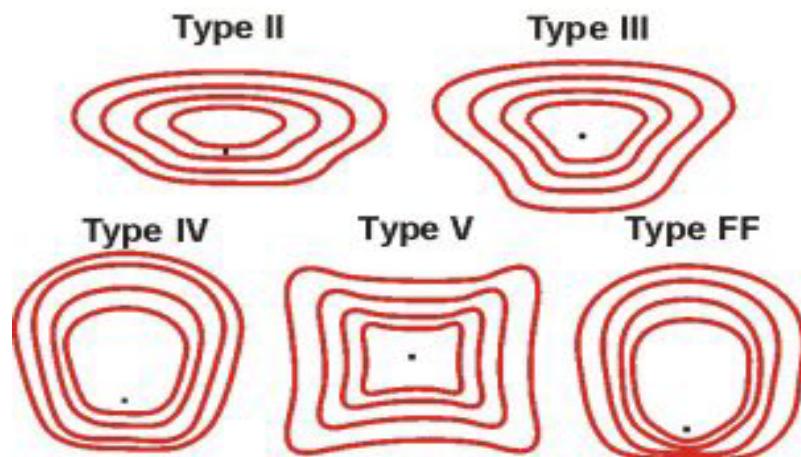
Do FCO fixtures demand more poles? No! There is less glare, and with less glare you need less light for the same visibility. We still hear the need for more poles, but these assertions are based on the original FCO fixtures from the 1980 and 1990s. The current fixtures are designed to not require more poles. If you think about it, why would a manufacturer make a

fixture that works poorly in such a competitive industry? All large manufacturers make and market FCO fixtures. So lets use them.

The City of Vancouver has streetlights, but the city doesn't control the extent and brightness of commercial signage. As a motorist, all you see down the main city streets are light bulbs and reflected light off wet pavement. You literally can't see someone running out into the street. Even traffic lights are lost amid the confusion of lights. Too much glare is down right dangerous. Adopt a lighting policy to limit the lighting of commercial signage.

We have seen parking lots and even roadways poorly illuminated. This usually occurs when the lighting design was not engineered and the fixture with the wrong light distribution pattern was installed. Reflectors in fixtures can be selected to uniformly illuminate a given area with minimal glare and light trespass. A Type V light distribution can be used for a parking lot and Type II distribution for a roadway.

If it is so easy, why isn't it already being done? That is why I am here!



A Few “Readable” Sources and Reference Material

www.ecologyofthenight.org/

Ecological Consequences of Artificial Night Lighting, Rick and Longcore,
Island Press 2006 ISBN 1-55963-129-5 [extensively referenced in this paper]

The Influence of Street Lighting on Crime and Fear of Crime, S. Atkins, S. Husain and
A. Storey, Crime Prevention Unit Paper No. 28, Home Office Crime Prevention
Unit, 50 Queen Anne's Gate, London SW1H 9AT

City of Ottawa Right-of-way Lighting Policy, and the
Dark Sky Preserve / Urban Star Park Program (RASC)
(www.starlight-theatre.ca/LT-POLLUTION)