

Note: The October 12, 2017 Whidbey Audubon Society program was “Shedding Light on the Role of Dark.” Joe Quintana and Jay Adams presented a program about the hazards to wildlife from too much outdoor night lighting. They also discussed what is being done locally and globally to alleviate the problems.

Because not all Audubon members were present and additional information is now available, Joe and Jay have kindly written two articles about these issues. These important articles are quite extensive, so we thought we would place them on the website where they will be easily available to more readers.

Lighting Up the Night Harms All Life On Earth

by Joe Quintana

Since the earth’s creation nearly four billion years ago, life on earth has been influenced by the cycle of day followed by night. This cycle is called the circadian rhythm and it affects all multicellular organisms. But today, Light at Night (LAN) is disrupting these ancient rhythms, with harmful effects for all living things, from birds to turtles, to humans and plants.

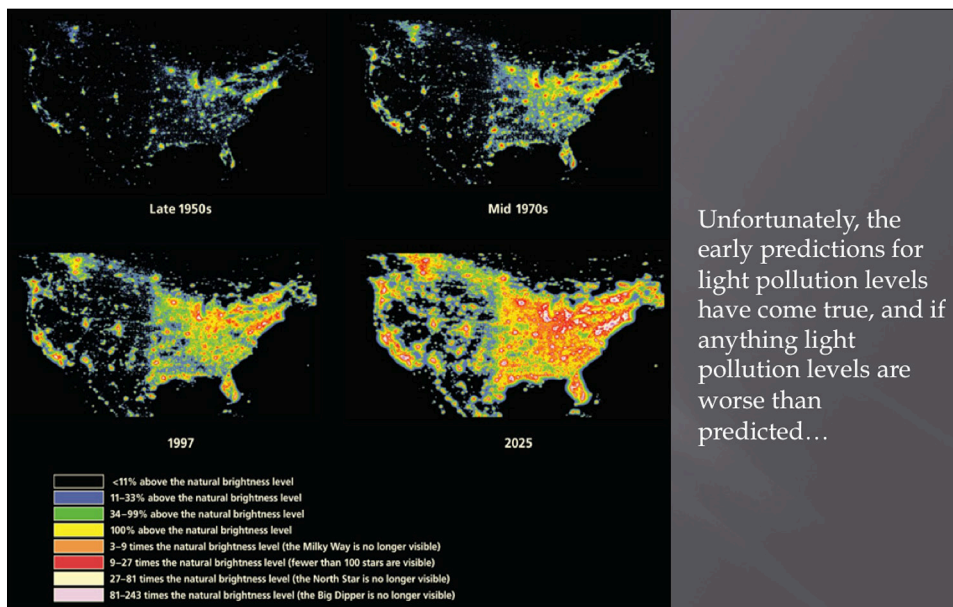
Astronomers became so concerned that light pollution was interfering with their ability to see the stars that in 1988 they formed the International Dark-Sky Association (IDA). They were quick to see that excessive lighting was doing a lot more harm than obliterating the beauty and wonder of the night sky. And that the problem was immense and growing.

The Nobel Prize committee, which recently honored the three scientists whose work established the scientific basis for circadian rhythms, explains the effect of this age-old cycle on humans this way:

With exquisite precision, our inner clock adapts our physiology to the dramatically different phases of the day. The clock regulates critical functions such as behavior, hormone levels, sleep, body temperature and metabolism.

Interrupting the circadian rhythm by creating light — when your body says it should be dark — can have profound consequences.

“Disruption of the circadian clock is linked to several medical disorders in humans, including depression, insomnia, cardiovascular disease, and cancer. Studies show that the circadian cycle controls from ten to fifteen percent of our genes. So, the disruption



Unfortunately, the early predictions for light pollution levels have come true, and if anything light pollution levels are worse than predicted...

The chart here illustrates the extent of over-lighting in the U.S. Excessive lighting in Europe is even worse and the rest of the planet is catching up quickly, particularly in the Asia. Areas in yellow are 100 percent above natural light levels. Red signifies nine to 27 times more than natural.

tion of the circadian cycle can cause a lot of health problems,” says Paolo Sassone-Corsi, chairman of the Pharmacology Department at the University of California, Irvine, in *EnviroNews*, a magazine of the U.S. National Institutes of Health (NIH).

Breast cancer — the leading cause of cancer incidence and death in women worldwide — is of particular concern. NIH notes that while causation has yet to be proved, the higher the nighttime levels of light, the higher the levels of breast cancer.

In the NIH’s own words: “Nighttime light levels codistribute with breast cancer incidence worldwide.” This correlation led the American Medical Association (AMA) to recently adopt guidelines to limit outdoor lighting at night, especially LED lights that are in the particularly harmful blue-rich white light spectrum. More on that later.

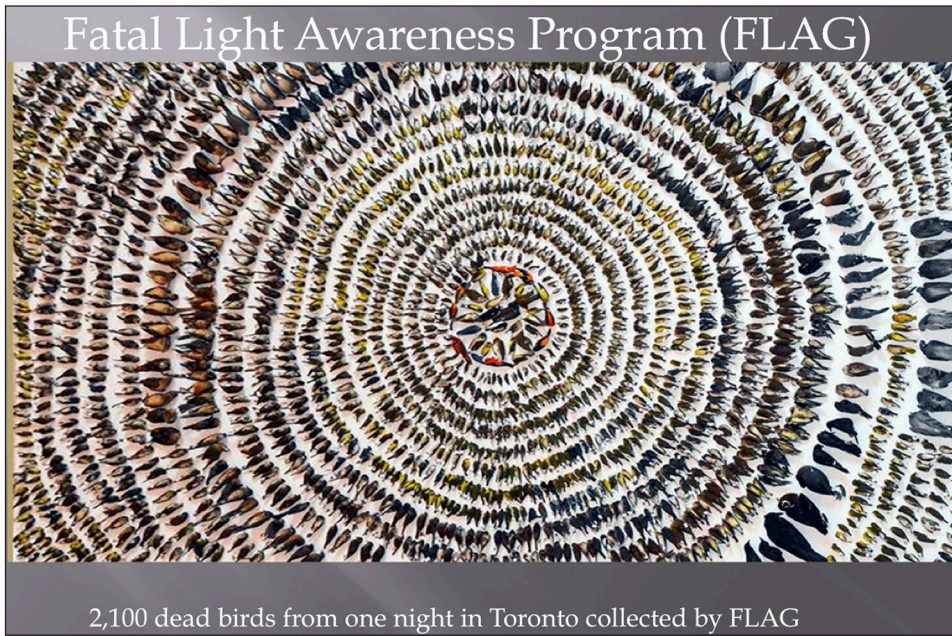
The impact of excessive light on other forms of life is even more dramatic.

That changing the light patterns would alter plant life is obvious. We all know the living relationship between light and plants. It would seem just as obvious that excessive lighting affects wildlife — especially nocturnal species.

We all know moths die from their fatal attraction to artificial light. Less known is that another important pollinator — nocturnal bees — also are attracted to artificial light, and sometimes suffer the same consequences. We also know the self-evident — that hunting and foraging at night by nocturnal animals, including bats, are disrupted by the near-constant state of light.

As in human studies, the science

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FLAG Canada's Annual Bird Display/flap.org, Royal Ontario Museum, 2016

These 2,100 birds, recovered by flap volunteers, died in window collisions.

behind the effects of artificial light on wildlife is young. Still, what does exist is compelling.

The leading study is of sea turtles. The study found that turtle hatchlings — who in nature swim to the light for their first breathe of air after birth in the ocean — were dying at alarming rates because they mistook artificial lights for the moon. As they crawled to their false moon they were run over by cars or preyed upon by predators. These findings, and the obvious implications for other wildlife, caused the State of Florida to pass the nation's most stringent light pollution laws.

The damage done to birds is horrific.

As many as one billion birds a year are killed by running into buildings needlessly lighted at night. Below is a photo of birds who died from building collisions in just one night in Toronto.

More recently, the National Academy of Sciences on October 2, 2017, published a seven-year study of the effects on birds of the 9/11 remembrance ceremony in New York City, where 88 spotlights are pointed toward the night sky. In just seven nights, 1.1 million birds attracted by the lights were thrown off their migratory

paths, their bird calls changing in distress. When the lights were turned off, their calls returned to normal and they resumed their migration. Had the lights been left on those 1.1 million birds would have circled the lights until they fell dead from exhaustion. It is heartening that as news of this study has spread some New York building owners are now voluntarily turning off their lights at night.

Good lighting is a good thing.

The world was dark and dangerous before the advent of artificial light. The safety and security provided by good lighting is unquestionable. But like oil and opioids, in the 138 years since Thomas Edison commercialized electric light we have over-indulged in the benefits of nighttime lighting and over-turned the natural state, with grave and growing consequences for ourselves and the planet.

The problem essentially is three-fold — the amount, the color and the direction of light.

The evidence of excessive lighting is seen most dramatically in “sky glow,” that eerie haze of light that covers most cities like a dome. But sky glow is merely the collective result of too many individ-

ual lights emitting excessive amounts of light and allowing that light to point or drift upward. Much of the damage caused by artificial lighting can be mitigated by ensuring that lights are shielded so they point down.

Importantly, the problem has gotten much worse as the result of a well-meaning attempt to reduce global warming by converting old and inefficient sodium lights to LED. It was thought that since LEDs use less energy, there would be fewer fossil fuels burned. Hence, there would be less carbon emissions. However, this theory has two important flaws. While LEDs do use less energy, in practice we are using more of it. In the process, we also are inhibiting the night's natural ability to cleanse the air of pollutants.

The result is that global light pollution is increasing at a rate of two percent per year.

This according to a five-year study of satellite images by an international team of scientists published November 22, 2017 in *Science Advances*. The team found that while LED lighting is more efficient, we have more than countered the gains in efficiency by using even more light. Economists would not be surprised that when something is made cheaper more is used. Says the IDA, “The findings challenge the assumption that increases in the energy efficiency of outdoor lighting technologies necessarily lead to an overall decrease in global energy consumption.” In short, the projections of energy savings by the conversion to LED lighting failed to account for market forces.

A second confounding factor: The Cooperative Institute for Research in Environmental Studies has found that night cleansing (of pollutants) is slowed by 7% by sky glow above cities and can increase the chemicals that create ozone pollution by up to 5% the next day. (This is because light inhibits the natural night time formation of the nitrate radical NO₃, which breaks down chemicals that form smog and ozone pollution.)

The color of light is as important as the amount and direction of light.

The color of light, or more accurately the color temperature of light, is measured on the Kelvin Scale. A beautiful red-orange sunset is about 1,500K. Toward the other end of the spectrum, a high-intensity xenon auto headlight carries Kelvin values of between 4,000K — 5,400K. A brilliant-blue clear sky is 12,000K. Beyond that is ultraviolet light, which insects and birds see, but humans do not.

Blue-rich light during the day is beneficial, but at night it interrupts circadian rhythms and worsens sky glow because it has significantly larger geographic reach than lighting consisting of less blue. The problem has been worsened as the worldwide conversion to LED lighting continues.

Most LED lights emit bluish light in the 4,000K to 5000K range. Citizen rebellions against the glare and intensity of high-Kelvin LED lights and greater knowledge of their harmful effects is changing that equation somewhat, but resistance from lighting providers, utility companies and institutional users like banks and oil companies has impeded progress. But the fact remains that the lower the color temperatures of lights at night the better it is for all living things.

To protect human health, for example, the AMA recommends artificial light be used only as necessary, that lights be shielded, that lights be pointed only to where they are needed and that lights have values of no more than 3,000K.

Florida goes even further. In addition to light shields and point-down requirements, it allows only sodium streetlights, which have values of around 2,200K. And to protect sea turtles, only yellow “bug lights” of no more than 50 watts are permitted near beaches. Both the AMA and Florida call for timers and motion detectors to limit the use of light to only when it is actually needed. Which brings us to the issue of lighting for safety and security.

Brighter Does Not Mean Safer.

There is no clear scientific evidence that increased outdoor lighting deters crimes, but a 1996 study by the Rensselaer Polytechnical Institute documented that most people have a greater “sense of security” when bright lights shine.

“We have very little confidence that improved lighting prevents crime,” says a 1997 National Institute of Justice report. A 2011 study of London street crime similarly concluded that there is no good evidence that increased lighting reduces total crime.

Bad lighting can even increase crime and vandalism. The Chicago Alley Lighting Project, www.darksky.org/wp-content/uploads/2014/09/Chicago-Alley-Lighting-Project.pdf, showed a clear correlation between brightly lit alleyways and a 21% increase in crime. And it stands to reason that graffiti artists need light to do their work and for their work to be seen at night.

Marcus Felson, a Rutgers University criminology professor, in a New Yorker magazine article summarizes lighting security science this way: “Lighting is effective in preventing crime mainly if it enables people to notice criminal activity as it’s taking place, and if it doesn’t help criminals to see what they’re doing. Bright, unshielded floodlights — one of the most common types of outdoor security lighting in the country — often fail on both counts, as do all-night lights installed on isolated structures or on parts of buildings that can’t be observed by passersby (such as back doors). A burglar who is forced to use a flashlight, or whose movement triggers a security light controlled by an infrared motion sensor, is much more likely to be spotted than one whose presence is masked by the blinding glare of a poorly placed metal halide “wall pack.”

Street lighting may not improve road safety either, in large measure because trucks and automobiles light their own way. A 2015 study published in the Journal of Epidemiology and Community Health

found that streetlights don’t prevent accidents or crime, but do cost a lot of money. The researchers looked at data on road traffic collisions and crime in 62 local authorities in England and Wales and found that lighting had no effect . . . When risks are carefully considered, local authorities can safely reduce street lighting, saving both costs and energy.”

Or, as the IDA says, “A dark sky does not necessarily mean a dark ground. Smart lighting that directs light where it is needed creates a balance between safety and starlight.”

Glare emitted by unshielded, high-intensity lighting is another reason most outdoor lights do not make us safer on the road or from criminals, or even just walking.

Glare decreases safety because it shines into our eyes and constricts our pupils. This can not only be blinding, it also makes it more difficult for our eyes to adjust to low-light conditions. As the AMA says, “Glare from nighttime lighting can create hazards ranging from discomfort to frank visual disability.” Anyone



Fully shielded lighting is safer, more efficient, and costs no more than non-shielded lighting

who has been blinded by on-coming, bright-white headlights can testify to that.

How glare diminishes security and safety is easily seen in the photo below. Note how the unshielded “glare bomb” makes the ground as well as the man harder to see. It can be dangerous to walk under lights that glare.

What you can do — Dim Some.

Use only what you need and lower bulb wattage. You probably need less than you now are using. Ensure lights are no more than 3000K. Shield lights so they point down and use motion detectors.

There is now at least one company, Sengled, *sengled.com*, selling motion detecting light blubs and spotlights. These “smart” LED bulbs turn on when motion is detected and turn off 90 seconds after movement ceases. They can be dimmed, timed, remotely turned on or off, and work with home assistants like Amazon Alexa and Google Assistant. The bulb color temperature is 2,700K, while the spotlight is 3,000K. At \$9.99, they are pricier than “dumb” LED lights, but one heck of a lot cheaper than motion detectors and way easier to install. For motion detection, just screw in the bulb. The rest of the smart features require simple installation of a free app.

Spread the word.

Most people know little about the dark-sky movement and even less why it is important. So tell your friends, neighbors, co-workers and anyone else you can think of about the dangers of light pollution and how they can help.

Don’t forget to post on Facebook, Twitter and blogs. You can also write newspapers and contact your elected officials. Complain if necessary. Light pollution is against the law in Island County, but understaffed officials only respond to complaints. Lastly, most utilities, including Puget Sound Energy (PSE), will install shields on street lights but only on request.

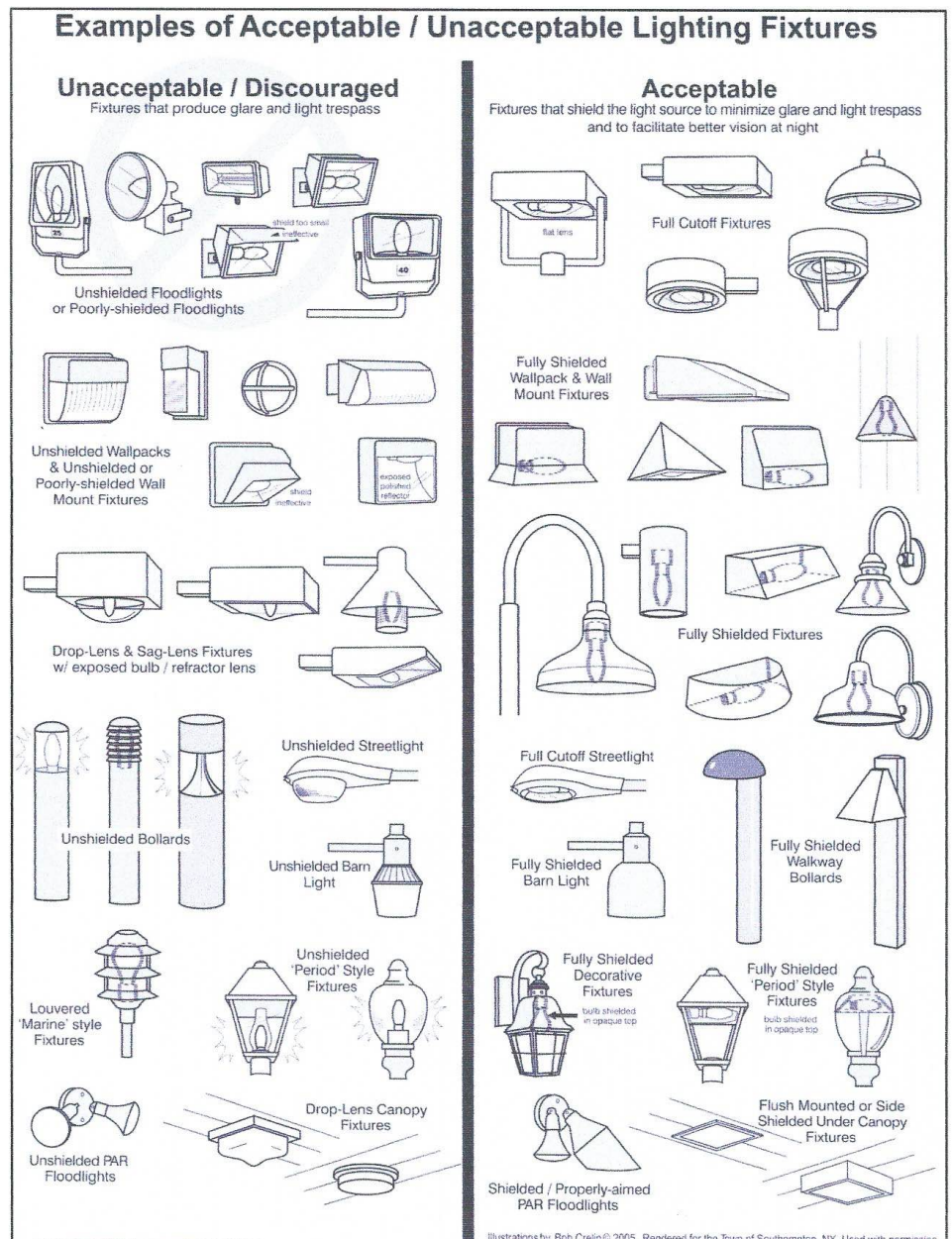
Environmental leadership is critical.

For all the right reasons, the environmental community led the fight to convert to LED lighting. But it has not worked as well as hoped and the growing harm of light pollution must be reversed for the sake of all living things. We have a moral obligation to undo the unforeseen harm done.

The IDA — admirably, courageously

and doggedly — has been leading the fight against light pollution, but it has neither the resources, the networks nor the political clout that the environmental community enjoys. Together, the IDA and the environmental community can turn the tide.

Let’s do it for the critters, and for ourselves. And so that once again we can see, wherever we are, the true beauty of the night.



Dark Skies text amendments, *Planning and Zoning Commission*, March 13, 2017, City of Ketchum Planning and Building Department

This Little Light of Mine: *More Ecological Consequences of Artificial Light at Night*

by Jay Adams

Much of the concern about the negative consequences of artificial light at night has resulted from an increasing understanding of the vast number of birds killed, injured or in other ways, stressed each year during migration from contact with lighted buildings, transmission towers, light ships, off-shore drilling rigs, lighthouses, and other sources of up-shining light. Much of the reaction to these consequences has focused on retrofitting or replacing outdoor luminaires so that their light does not shine up. Many communities, including some on Whidbey, are switching to light-emitting diode (LED) streetlamps as a means of reducing energy costs. The replacement luminaires are configured to shine no light above the horizontal plane of the fixture. This is good news for the birds, but it does not address, and may even increase, the negative ecological consequences of artificial light at night on earth-bound creatures, nocturnal and otherwise, that need the dark in order to live. We humans are on that list.

Here are some of the ways that artificial light at night can negatively affect life forms others than birds:

- Sea turtle hatchlings can lose their way in the presence of artificial light at night (henceforth ALAN) and thus fail to reach the sea.
- Snakes, salamanders and frogs restrict movements on full-moon nights to reduce the chances of predation. ALAN alters this behavior. Every night becomes a full-moon night. Salamanders delay feeding in lighted areas and can even lose their important homing ability.
- Some tree frogs stop producing territorial song in the presence of ALAN. No singing means reduced breeding, as the singing attracts mates. For frogs, the dark-light circadian schedule regulates physiological functions, including production of the hormones that control fat accumulation in preparation for winter

hibernation and the timing of egg production.

- Squirrel Tree Frogs forage at lower light levels than do Western Toads. Under ambient light conditions, their forage times do not overlap. ALAN changes this timing, resulting in foraging competition.
- For many fish species, feeding, schooling, and migration depend on specific light intensities. Fish schools may disband and cease feeding in the absence of needed light cues. ALAN can cause temporary blindness in fish, leading to a greater risk of predation.
- Varying underwater light levels are used by fish to partition their otherwise shared feeding grounds. ALAN can destroy the subtle differences on which the fish rely.
- Salmon change their migration behavior and distribution in night-lighted areas. Increasing ALAN raises the chances for salmon, herring, and sandlance mortality. Predators take advantage of lighted spillways, fish ladders, and bridges. Harbor seals congregate under artificial light to consume juvenile salmon. In one experiment, turning the lights off reduced salmon predation to natural, lunar-driven levels.

Artificial light at night (ALAN) is not just a problem for anadromous fish. Light levels in urban lakes and ponds as well as streams, estuaries, and the pelagic zone can equal or exceed full moonlight, altering behaviors and upsetting biological clocks.

Not really fish, but mollusks, California Market Squid have switched from daytime reproduction to nighttime reproduction in the presence of lighted fishing and research vessels. The result has been increased squid mortality.

Insect species are especially sensitive to artificial light because they have no ability to resist light stimulation. They can become fixated, entrapped, or they may

crash, all of which reduce populations over time.

Fireflies can lose the ability to see and make use of their flashing signals.

Nocturnal pollinators reduce visits to plants in the presence of artificial light. In one study, this resulted in 13 percent less fruit set even though the plants also received the normal number of visits by daytime pollinators.

Like other insects, moths have many independent photo-receptive circadian pacemakers located in different types of tissue. Sunlight synchronizes them. Synchronization of life cycles with lunar cycles may help moths navigate, mate, oviposit, feed, and avoid predators. By simulating moonlight, ALAN can disturb or alter these behaviors.

It can also rearrange predator and prey relationships. Zooplankton exhibit vertical migration through the water column in response to small changes in light intensity. Organisms residing deep in the water column during the day ascend at dusk to shallower depths where they feed, then return to greater depths at dawn. On moonlit nights, migration is put off. ALAN routinely suppresses zooplankton vertical migration. In artificial light, every night is moonlit.

Stream macro-invertebrates such as Mayfly nymphs and bottom-dwelling crustaceans exhibit stream drift. They live on the bottom, detach, and drift with the current to forage at night. This is not passive but active drifting. It is cued by lowlight conditions.

Mammals are not immune from the effects of artificial light at night. Their physiological, behavioral, reproductive, communications and other effects are at work, too. Coyotes, for example, howl more frequently at the time of the new moon. This allows them to communicate to reduce trespassing by other flocks or to assemble packs to hunt. ALAN disrupts these behaviors.

Some bats have learned to feed at streetlights, so much so that such behav-

ior is now considered part of the normal life habit of many species. This adaptation may reward the bats, but it can have dramatic negative effects on the insects on which bats prey.

ALAN affects plants as well as animals.

Their photo-receptors govern germination, phototropism, conversion from the vegetative state to the flowering state, flower development, fruit development, and dormancy, and help plants measure day length, light quality, light intensity, light direction, and light duration. In darkness, plants maximize stem growth and elongation. In the light, leaf formation and leaf expansion are maximized. Alter this natural order of things and plants suffer the consequences.

ALAN can also rearrange relationships between members of a living community. Sometimes, ALAN can benefit a member of the group. But that benefit comes at a cost to some other member. Thus, crows have learned to roost in lighted areas, ostensibly to avoid predation by owls. Such behavior is good for the crows, but potentially bad for the owls. Such balances are key to our understanding of the effects of artificial light at night.

An emerging concern related to artificial light at night is not the light itself but the color of the light. This concern is deepening as a result of the colors of light emitted by LED lamps. That color is measured in terms of Kelvins. The higher the K-number, the more the light is made up of shorter blue wavelengths — which make the light look bright white. For humans in particular, these short blue wavelengths can disorient human vision in ways akin to snow blindness. The eyes of older adults in particular often have trouble adjusting to rapid light/dark changes such as those experienced while driving at night in areas lit by streetlights with LED lamps above 3,000K.

But more than temporary loss of visual clarity, artificial light at night, and in particular, short wave-length blue light, can throw off our biological clocks. Humans need darkness at night because darkness stimulates the production of melatonin

and other hormones which mediate not only activity patterns but almost every other physiological or behavioral rhythm, including tumor growth. *This is true not only for us and other mammals but for nearly every other life form, too.*

An emerging concern related to artificial light at night is not the light itself but the *color* of the light.

The significance of this was recently documented in two ways. First, the American Medical Association, at its annual meeting in 2016, adopted an official policy statement about street lighting. Pointing out that LED streetlamps rated above 3,000K have five times the ability to alter circadian sleep rhythms, not to mention their effects on driving safety, the policy recommends not only that communities install luminaires at or below 3,000K, but also that the lights should be *dimmed* during off-peak hours. Second, in October 2017, the Nobel Prize for science was awarded to three physicians for their work to identify the workings of Circadian Rhythm. Specifically, the doctors identified the gene that encodes a protein that accumulates in cells at night, and then is degraded during the day. Their work was done with fruit flies, *but they now realize that biological clocks function by the same principles in the cells of other multi-cellular organisms, including humans.*

“With exquisite precision,” according to the prize story on National Public Radio, “our inner clock adapts our physiology to the dramatically different phases of the day and night. The clock regulates critical functions such as behavior, hormone levels, sleep, body temperature and metabolism.”

Tamper with those functions and we open ourselves to nervous conditions, language difficulties, analytical challenges, long-term memory impairment, tumor development and growth, diabetes,

depression and obesity.

Fortunately, there are steps all of us can take to reduce or eliminate the negative effects of artificial light at night. The most obvious step is to turn off all outdoor lighting that is not absolutely necessary.

Other steps include replacing current fixtures with lamps that not only don't shine up, but that also do not shine out. In other words, choose a fixture that only emits light straight down. In addition, only use bulbs rated at 3,000K or less. A quick internet search will locate such lights in many styles and price-ranges.

In addition, ask Puget Sound Energy to add shields to any streetlights that shine on or at your property. This includes the newer LED lights that are being installed in some communities on Whidbey.

Indoors and out, use only LED bulbs rated 3,000K or lower (2,700K is becoming the standard indoor household rating). Bulbs are now available that mimic the three-way bulbs that once were common, only these bulbs come not in three watt-ages, but in three K ratings. I have one where I can choose 2,700K, 2,500K or 2,300K depending on the task at hand and the time of day. Twenty-three hundred approaches the orangey firelight look of the older high-pressure sodium streetlamps that can still be seen from place to place. The lower the Kelvin number, the less the light negatively affects our circadian clocks.

Finally, one can also download laptop, tablet and smart-phone apps that lower the K-value of the light emitted by your devices. The apps use your location to identify the times of dusk and dawn and then change the color of the screen to be more circadian-rhythm friendly, according to settings you control.

For more information, please see Catherine Rich and Travis Longcore, editors; *Ecological Consequences of Artificial Night Lighting*. Island Press, 2006. An eBook version is available. An internet search on the book title will yield many additional resources, including detailed references to recent medical findings.