MidCoast Senior College – Winter Wisdom Series

"Preserving Maine's Dark Skies"

February 14, 2024

Curtis Memorial Library, Brunswick, ME

Robert Burgess, Presenter

[Slide 1]

"Silently, one by one, in the infinite meadows of heaven, Blossomed the lovely stars, the forget-me-nots of the angels." So said Henry Wadsworth Longfellow in Evangeline, A Tale of Acadie.

Good afternoon, friends of Maine Senior College's Winter Wisdom Series. My name is Robert Burgess and I want to thank Maine Senior College for giving me the opportunity to discuss this important topic of Preserving Maine's Dark Skies, and thank all of you for being here. As you will hear over the course of this talk Maine has the largest contiguous area of truly dark skies east of the Mississippi, but like in so many places around this country and around the world we are at risk of losing our precious darknesss, with many downstream consequences. But there is good news, too, that I'll share with you.

[Slide 2] The organization I represent, Southern Maine Astronomers, is a 501(c)(3) corporation, provides a home for people with a passion for astronomy and a desire to share that with others. We are a group of more than 100 amateur and professional astronomers who provide outreach to the public, including school kids, through star parties and talks. We are headquartered on Brunswick Landing and are celebrating our 20th anniversary this year. We host monthly meetings on Zoom, featuring scientists and space flight engineers discussing cutting edge research into astronomy, astrophysics and scientific missions exploring our universe. We also host star parties and solar observing

sessions around southern and Midcoast Maine where we share views through club and member telescopes, provide laser-pointer constellation tours and provide telescope help to anyone having problems with equipment. All of our events are free and open to anyone with interest and are advertised on our website. Brochures about SMA are on the table where you entered today, so please be sure to pick one up if you'd like more information.

One of our objectives as a club is to educate about the risk of losing our night skies to light pollution, a problem that is hard to reverse after its effects are felt. Light pollution needs to be addressed immediately because, even though it can be instantly mitigated (by turning off lights), its consequences, such as loss of biodiversity, cannot.

In a world full of problems this is not the biggest. But as I hope to convey to you today, this is a serious one, one whose impact is only just beginning to be understood and which could be profound. But unlike so many of the larger societal problems we face, this one can be addressed at the local level where we live and is one where each of us can have a positive impact on the natural world around us.

[Slide 3] **Definitions.** So what is light pollution, and why is it yet another problem we have to concern ourselves with? **Light pollution is the human-made alteration of outdoor light levels from those occurring naturally.** Earlier definitions focused on misused or misdirected light, such as streetlights and billboards and commercial buildings. This revised definition is much more wholistic, looking to all environments that have been altered by human-made light. That being said, please understand that our goal, my goal, is not "anti-light." There is no desire to go back to the Dark Ages and eliminate outside lighting! Our goal is to deal with badly designed and wasteful lighting

that, as you will see, has many negative consequences that are not readily apparent. Its effects include:

- Negative impacts on a variety of environments and ecosystems, including human health;
- Sky Glow – the glow over cities and towns impairing our view of the night sky and astronomical research (including efforts to track down potentially dangerous asteroids that could be on a collision course with Earth);
- Glare – the potentially dangerous interference with people's sight while walking or driving;
- Light Trespass – unwanted light shining onto an abutter's property or into their home;
- Higher taxes and prices – inflating the cost of municipal and business operating budgets through more electricity use; and
- Global warming – since most electricity is still produced in fossil fuel-burning power plants, wasting electricity increases noxious emissions from power plants that contribute to the global warming process, as more electricity needs to be generated.

Let's spend a few minutes on each of these, but first a quick explanation of visible light and the electromagnetic spectrum.

[Slide 4] **The Electro-magnetic Spectrum:** This slide illustrates the electromagnetic spectrum, of which visible light, that we can see with our eyes, is just a small part. Everything on this spectrum, from high energy Gamma Rays and X-rays on the right to the lower energy radio waves on the far left, are all forms of "light." They are radiation at different frequencies. Visible light to us humans is seen in that narrow band of frequencies, from about 400 nanometers to 700 nanometers. That's it. It's because of this that we have developed many space-based telescopes that you have probably

heard of such as the James Webb, designed to see in the infrared and the Compton X-ray observatory, observing the universe at high-energy X-ray levels that we cannot see with our eyes. And note the color breakdown of the visible light spectrum, with blue at the higher frequency level and red at the lower frequency range of visible light. We will come back to this concept when talking about a new form of lighting – LED's – later in the talk.

Impacts on Environments and Ecosystems

[Slide 5] **Most animal life is nocturnal.** It is estimated that 60% of animal life is nocturnal. This makes sense since we live in a world where it is light half the time and dark the other half. Animal life has evolved over hundreds of millions of years around the cycle of the Sun and Moon, with innumerable adaptations having been made by creatures of all types, from primates and mammals to invertebrates and amphibians and insects. Artificial light has existed for a mere fraction of that time – about 145 years – too soon for meaningful adaptation to have occurred. Light pollution upsets the careful balance that evolution has established.

[Slide 6] Turning to Birds: Some birds migrate at night and use moonlight and starlight to guide them. The light from urban centers can cause them to stray off course and wander into cities, sometimes confusing them so much that they die of exhaustion or fly into buildings and are killed. It has been estimated that as many as one billion birds die annually from collisions with buildings, many of which occur from illuminated buildings at night. In addition, artificial light can disrupt their cycles and cause them to migrate too early or too late or to lay eggs and hatch them before adequate foods sources are available to feed their young.

[Slide 7] **Insects:** Half of all insects are nocturnal – they use darkness to find food and mates. Many are pollinators, particularly for night-blooming plants. Artificial light attracts insects, drawing them in where they become easy prey for others. The coloring on the wings of ghost moths is less visible under artificial light, disrupting important aspects of their mating. Fireflies depend on the darkness to send their bioluminescent signals, using the signals for mating and to warn of predators. Stray light interrupts their ability to communicate and reduces populations by disrupting mating. Birds and insects use part of the electromagnetic spectrum we cannot see, operating in the ultraviolet, which is disrupted by artificial light.

[Slide 8] **Mammal species:** Nocturnal animals sleep during the day and do most of their hunting and food gathering at night. Light pollution changes their cycle and transforms the dark of the night into a different, confusing and more dangerous environment, particularly for prey. Most of the world's 6,000 mammal species move around at dawn and dusk for feeding and mating. Artificial light into their habitats disrupts this behavior. For example, thought to be daytime hunters only, more research has determined that cheetahs actually do half of their hunting at night.

[Slide 9] **Amphibians, reptiles and marine life:** Many animals depend on nighttime for their reproductive cycles. For instance, frogs and toads croak at night as part of their reproductive ritual. Light disrupts this ritual because the frogs do not know when it is time to croak. Frogs and toads have been known to cease their mating activities altogether in areas where light pollution occurs. More well known is the fact that newly hatched sea turtles on beaches will be confused by light on land and will be drawn away from the safety of the ocean, only to become prey or killed when crossing roads. Other forms of marine life respond to light – the reproduction of

corals and the laying of eggs by clown fish are light sensitive. Certain fish, crabs and mollusks respond to lunar light cycles that are disrupted by artificial light.

[Slide 10] Plants and Trees: Plants are trees are affected by artificial light. Light can cause certain trees to bud early, subjecting them to the impact of late frosts. Similarly, the shedding of leaves and preparation for winter can be delayed by artificial light. In the slide image you can see semicircles of green emanating from the light dispersion pattern of a nearby streetlight. The soybeans in the picture should be dying back like the rest of the field, but those in the area covered by the streetlight remain green and do not follow harvesting patterns.

[Slide 11] **A great book:** For a lot more information on the impact of light pollution please check out "The Darkness Manifesto" by Johan Eklof, a Swedish conservationist and bat scientist, who chronicles the impact on many forms of animal life, including humans, from exposure to artificial light. As we all know, everything is connected and when light pollution impacts one species, this affects other species that depend on it for survival. We have not yet developed the sensitivity to the impact of light in environments where it doesn't belong, like we have to other environmental impactors such as water runoff or toxic substances. More research, and more public understanding of the issue, is required.

<u>Turning to Sky Glow, Loss of Cultural Heritage and Scientific Impacts</u>

[Slide 12] The Bortle Scale: This slide is another background informational slide on terms used when discussing light pollution. The so-called Bortle Scale is a nine-level numeric system for judging light pollution in various settings. Portland and Bangor may be levels 6 and 7 on this chart where more suburban and rural areas in Maine are Bortle 4 and 5.

The skies in Maine's two Dark Sky International certified Park and Sanctuary are Bortle 2 to 1.

[Slide 13] **Light Pollution Map of the World:** Using the **New World Atlas of Artificial Night Sky Brightness** it is estimated that 80% of the world's population lives under sky glow; in the United States and Europe that number is closer to 99%. Beyond that, it is estimated that 80% of our fellow Americans cannot see the Milky Way from where they live, living, as they do, under the equivalent brightness of a full moon – or worse – caused by light pollution. Indeed, when an earthquake blacked out Los Angeles in 1994 the police received many calls from worried residents about the bright bands crossing the sky, which was, of course, people seeing the Milky Way for the first time! That same city of Los Angeles now casts a glow that can be seen 200 miles away.

PAUSE

For probably at least the last 200,000 years, since man walked upright, the sky was a source of inspiration and wonder – and it humbled us. The stars, planets and the Moon were interwoven into our everyday lives, affecting decisions on hunting, planting, traveling and navigating and countless other human endeavors. We are imbued with an innate wonder of what's out there and our place in it. It has inspired poets, artists and scientists for millennia. It provides us with a context for our existence in ways few other experiences can. When we lose this opportunity, we lose an essential component of our humanness. A member of the Abenaki tribe indigenous to Maine quoted in the film "Defending the Dark" described how their culture sees the stars as campfires of their departed families and tribal members, with connections made every clear night. That beautiful cultural image that is being lost to light pollution.

[Slide 14] **US Light Pollution Map:** Zooming in on the United States is a light pollution map may have you have probably already seen in one publication or another. It is

astounding. The megalopolis of Boston to Washinton is clearly seen as well as other major cities across the US and Canada. Without light pollution about 2,500 stars should be visible at night. Most people now see perhaps a few hundred, at best. In cities, it might be a dozen or so bright stars and a planet or two. From 2012 to 2016 the amount of artificially lighted area grew 2.2% each year according to satellite data. However, when those data were matched up with ground-based observations, including from citizen scientists, the growth rate in the spread of light pollution was revised to between 9 – 10% per year! It is attributed to organic growth, to overlighting, and the switch to blue-rich LEDs. This is an alarming trend.

If you look to the top right hand corner you can see Maine and a big area of black over the northern half of the state. It is this area especially, but also our own backyards, that we seek to protect.

[Slide 15] **Maine Light Pollution:** As the current slide illustrates we are experiencing the creep of light pollution in Midcoast Maine, but fortunately there are still dark areas to preserve. You can see all of the southern and coastal Maine communities you are familiar with. In this map, reds and yellows show higher levels of light pollution while blues and grays show lower levels of light pollution.

[Slide 16] **Localized Light Pollution:** It's not just a big city problem. On this next slide you can see a bright dot with a white center, characteristic of a major city in terms of intensity. What is it? It is Backyard Farms' 42 acres of greenhouses growing tomatoes for the northeast market. The company located in Madison, Maine because of cheap electricity costs provided by the municipally-owned hydro dam. The company extols its stewardship of using natural light as much as possible. But when the sun goes down it must resort to artificial light which has a dramatic effect on the area in terms of sky glow.

[Slide 17] **Images of Sky Glow:** Astronomical research has been impaired by sky glow. As lights from a city or other source shine up into the sky the light scatters off dust, water, smog, clouds and other aerosols in the atmosphere creating a light dome or glow over the city, washing out the stars from view. Sky glow has become so pervasive that many famous observatories near cities, such as the David Dunlap Observatory outside Toronto and the Yerkes Observatory outside Chicago, have unfortunately transformed themselves into historical sites and education centers. Even night vision training of our military is being affected by sky glow and light pollution near military bases, such that several Texas counties have had to enact certain light pollution controls if they have nearby bases.

[Slide 18] **Mount Palomar Observatory:** Even the historic and revered Mount Palomar Observatory in southern California, home of the 200" Hale telescope, is being assaulted by sky glow from nearby SanDiego County.

[Slide 19] **The Value of Awe in the human experience:** How many of you remember that first time you were under really dark skies? What was it like? Magical, wondrous, scary, even? For those experiencing it for the first time it's like having a veil removed from their eyes, or seeing something in technicolor from black and white! People are amazed that that same sky is right over their heads where they live, every night, but they can hardly see any of it. What a loss!

There is a growing body of scientific research and literature regarding the beneficial aspects of awe. In an April 2017 article in *Psychology Today* on "The Emerging Science of Awe and its Benefits" the authors found connections between the experience of awe and enhanced critical and creative thinking, improved health, and a greater sense of connectedness, leading to an increase in pro-social behaviors such as kindness,

self-sacrifice, cooperation and resource sharing. They said "Awe is also one of the few emotions that can reconfigure our sense of time and immerse us in the present moment."

To be sure, a dark sky is but one place in our world to experience awe. But given the significance awe can have in how we perceive ourselves and interact with others, is it really something we should allow to slip away from us? We need more, not less, awe in our lives!

[Slide 20] **The Inspiration of Dark Skies:** Once when visiting the Hayden Planetarium in New York City I got to meet the man responsible for developing their cutting edge planetarium programs, programs that are then used in planetariums all over the country. I asked him how he became inspired to the point of dedicating his adult life to the pursuit of educating others about astronomy and the night sky. He told me that it was the result of visiting his grandparents' farm, "outside of Waterville, Maine," when he was 10 years old where he saw a truly dark sky for the very first time. "It was awesome! I was hooked" he said! How many more such opportunities will there be to inspire other young scientists and educators, artists and poets, when we can no longer see the night sky? In Saint Remy, France, where Van Gogh painted "Starry Night," the Milky Way is no longer visible.

As Albert Einstein once said: **"The most beautiful thing we can experience is the mysterious. It is the source of all true art and science. He to whom this emotion is a stranger, who can no longer stand rapt in awe, is as good as dead: his eyes are closed."**

[Slide 21] Defending the Dark: There is an extremely compelling and informative film that debuted last year directed by Tara Roberts Zabriskie, titled "Defending the Dark." It's about light pollution **in Maine**, its effects, and what can be done to mitigate it by raising awareness. The film has been shown on Maine Public TV as well as PBS stations

nationwide. It is now available on demand on the PBS website. I highly recommend it to you.

Human Health Effects:

[Slide 22] Light Pollution's Effect on Humans: Stray light shining into one's bedroom can disrupt the body's circadian rhythm – the body's internal clock. Our body produces certain beneficial chemicals as we sleep, such as melatonin. Melatonin has anti-oxidant properties, induces sleep, boosts the immune system, lowers cholesterol, helps the functioning of the thyroid, pancreas, ovaries, testes and adrenal glands. Nighttime exposure to artificial light suppresses melatonin production, which is obviously not good for human health. Recent research in *The Journal of Neuroscience* and the *Journal of the National Cancer Institute* on studies involving shift workers, such as nurses, have reported increased incidences of cancer, including breast cancer, among patients with the brightest bedrooms, caused by having to sleep during the day. There is a growing body of scientific evidence, such as the 2016 American Medical Association's Report on the "Environmental Effects of LED Community Lighting," that document similar health consequences. This area of science is getting more attention – three American doctors received the Nobel Prize in Medicine in 2017 for their research into circadian rhythms.

From a global warming perspective, every photon we waste had to be generated somewhere. While our move to renewable sources of electricity is a welcomed and necessary change, the fact remains that in the United States 59%[1] of our electricity is generated in a power plant that burns some form of fossil fuel. Therefore, when we unthinkingly waste light we waste electricity: that extra generations necessarily increases the amount of carbon dioxide and nitrogen dioxide emitted into the atmosphere that are greenhouses gases. We also release particulate matter that

[1] 19% nuclear, 28% renewable

exacerbates asthma and other respiratory diseases, and sulfur dioxide that acidifies our lakes, streams and the ocean. In the face of these realities is it nonsensical to be wasting electricity carelessly through bad lighting!

[Slide 23] **Effects on Taxpayers and Consumers**: Excessive public lighting, especially street lighting, wastes taxpayers' money. According to the Dark Sky International the residential and commercial sectors used about 232 billion kilowatt hours of electricity for lighting, including street lighting, or about 6% of total US energy consumption. DSI estimates that about 30% of outdoor lighting is wasted due to poorly aimed fixtures, over-lighting, and lighting areas when not needed. This electricity use costs about $3.3 billion and its production releases about 21 million tons of CO2 annually. It would require the planting of 875 million trees each year just to counteract what is wasted.

Bringing this to the state level, according to US Energy Information Administration, Maine consumed about 11.2 million Megawatt Hours of electricity in 2023. If Maine follows the same pattern of usage and waste then the cost of this wasted electricity is over $26.2 million. I think we could all come up with better ways to spend $26 million than by shooting photons into outer space!

[Slide 24] – **Fear of the Dark:** Nyctophobia (fear of the dark), and the development of more efficient LEDs, has led to over-lighting certain areas. This has accounted for some of the increase in growth of worldwide light pollution, discussed previously. I don't think any of us would want to live in the housing presented in this picture. But drive around town some night and note what you see – it's here, too. Some of it is old and grandfathered in, but newer installations may not be meeting town standards.

[Slide 25] **Poor design under the guise of safety:** This slide represents another example of poor design and over lighting hidden under the guise of public safety. The result is glare, an inability to read street signs, and light flooding into bedrooms where it is

affecting the health of residents. But it probably did lead to great sales of blackout window shades at local curtain shops!

[Slide 26] **Over-lit highways:** Cars do have headlights, but overzealous engineers and highway standards resulted in this grossly over-lit stretch of roadway. Ironically, transitioning from such brightly lit streets to darkened roadways can create its own hazards as eyes struggle to dark adapt.

[Slide 27] **Light Trespass:** Light trespass is probably the most common complaint in residential areas. It occurs when one neighbor over-lights their property, such as with an unshielded "barn burner" left on all night, sending light onto neighboring properties, disrupting neighbors' enjoyment of their own property and possibly affecting their sleep, and ultimately their health. Light trespass is a form of tort, or civil wrong, but there has been very little litigation to establish any case law in the area. But, consider this: if a neighbor were to leave a hose running all night onto another neighbor's property and flooding it, there would be no question a tort had been committed and the offending neighbor would be liable in damages. Light pollution does not appear to have risen to that same level of common sense understanding – yet.

[Slide 28] **Glare:** On a more readily observable basis, poorly designed and aimed light, of the wrong color temperature, can produce glare that can be hazardous to us as pedestrians and as motorists. Who in this room has not had to squint, sometimes frantically and with prayer in the face of blue headlights coming at you? That is glare, and if it gets bad enough it is considered to be "disability glare" – when the introduction of stray light into the eye reduces the ability to resolve spatial detail. And because the light is high in the blue end of the spectrum (remember our discussion of the electro-magnetic spectrum), it has more energy and scatters more. This is worse for older individuals because of internal changes to the eye caused by aging. Because Maine has the oldest population of any state in the country these considerations should be of

increasing importance as we design our roadways and sidewalks and attempt to control the type and placement of lights.

[Slide 29] **Whoa! Now that's glaring!** Can you read the sign in the foreground? It says "STOP!"

[Slide 30] **Does more light make us safer?** Glaring lights, and poorly aimed lights, can also create public safety hazards when the intent is to make places safer. In this slide we can see that a very bright and unshielded, unaimed light not only causes us to squint, but also creates dark shadows where assailants could hide. And note the dark, shadow-encased stairs.

[Slide 31] **Imagine a police officer on a chase:** A bright, unaimed, wall pack light, would cause a police officer chasing a suspect to squint as his or her pupils struggled to constrict to adapt to the bright, unshielded, light present on the scene. Note the dark shadows along the fence line.

[Slide 32] **A suspect lost in the shadows:** Once that bright light is shielded from our eyes we can see that there is a suspect standing in the gate! Excessively bright and unshielded, unaimed light does not provide safety – it creates a hazard! Numerous studies have shown there is no evidence that by following responsible outdoor lighting practices that crime increases. Remember that half of crimes are already committed in daylight!

[Slide 33] **The importance of light fixture design:** This slide from Dark Sky International clearly demonstrates the variety of light fixtures that are present in the marketplace and installed in our communities. The illustration makes a clear and understandable case for properly shielded lighting. Let me demonstrate. **[DEMO with penlight]**

[Slide 34] Not all lighting users or installers got the memo: These pictures were taken from around Brunswick. Our revised zoning ordinance, adopted in 2017, made no real changes to our outdoor lighting requirements. Both new and old required full cut-off shielding for outdoor lighting fixtures producing more than 2600 lumens (equivalent to an old "150 watt" incandescent bulb) and for no light to be emitted above the horizontal plane. Enforcement falls on the plate of our single Code Enforcement Officer who already has myriad other responsibilities and administrative duties. Some of the fixtures in these pictures may be grandfathered but others may be the result of poor or technically illegal installation.

However, in some positive news, the Times Record reported today that Brunswick has joined the six other communities of Augusta, Cumberland, Gorham, Portland, Sanford and Westbrook in Efficiency Maine's C-PACE program. The program offers low-interest, long-term loans for businesses making energy efficiency improvements to their operations, which could include outside lighting. It will be important to educate those businesses about recommended dark-sky appropriate lighting choices.

[Slides 35 and 36] Light Emitting Diodes: Light Emitting Diodes, or LEDs, have been with us in a significant way, since the 2010's as manufacturers starting producing white LEDs. LEDs are far more efficient than the incandescent, high and low pressure sodium and metal halide lights they replaced, using only about 20% of the electricity. They were also aimable and of extreme durability, having a service life of about 100,000 hours, about 20 years, so maintenance costs virtually disappeared. The correlated color temperature of these various bulbs are measured in degrees Kelvin, the same way star temperatures are measured. There was little not to like – except perhaps the correlated color temperature of the lamps, being heavily weighed in the blue spectrum.

[Slide 37] **Histograms:** These histograms of the spectra of light produced by various LEDs of increasing color temperature, show that LEDs in the higher color temperatures show a distinct spike in the blue range. As we have discussed previously, blue light scatters more than other wavelengths and produces more glare and more skyglow, both of which are bad. We should be doing all that we can to ensure the lights we install in our communities have the lowest color temperature possible. Because of the durability of these lights, the decisions we make today will be with us for a generation since maintenance is so infrequent. Lumen output is the same, so a bulb with a lower color temperature is not dimmer than one with a higher temperature. We are not sacrificing safety when we choose a fixture with a lower color temperature. **[Demonstration with bulbs]**

What's Being Done?

Fortunately, for the last 36 years, an organization based in Tucson, AZ, the International Dark Sky Association, now known as Dark Sky International, has led the fight to educate about light pollution and to do something about it.

[Slide 38] **Dark Sky International**: Through public outreach DSI provides solutions, public education and programs that inform audiences all over the world. DSI has chapters throughout the world. DSI also certifies Dark Sky Places[2]. At the end of 2023

[2] **International Dark Sky Communities** – cities and towns that adopt quality outdoor lighting ordinances and undertake efforts to educate residents about the importance of dark skies.
International Dark Sky Parks – publicly or privately-owned places protected for natural conservation that implement good outdoor lighting and provide dark sky programs for visitors.
International Dark Sky Reserves – reserves consist of a dark core zone that is surrounded by a populated periphery where policy controls are enacted to protect the darkness of the core.
International Dark Sky Sanctuaries – sanctuaries are the most remote (and often darkest) places in the world whose conservation state is most fragile.
Urban Night Sky Places – sites surrounded by large urban environs whose planning and design actively promote an authentic nighttime experience in the midst of significant artificial light at night, and that otherwise do not qualify them for designation within any other International Dark Sky Places category.

there are more than 200 International Dark Sky Places worldwide across six continents comprising almost 100,000 square miles. In 2020 Maine received its first certified Dark Sky Sanctuary through the Katahdin Woods and Waters National Monument just east of Baxter State Park. In 2021 Maine received its first International Dark Sky Park, the Appalachian Mountain Club's Maine Woods, covering the 100 Mile Wilderness portion of the Appalachian Trail. There is also an International Dark Sky Reserve at Mount Megantic, Quebec, just across the border from the Rangeley region.

[Slide 39] Dark Sky Friendly certification: DSI's Fixture Sale of Approval has been applied to thousands of products manufactured by more than one hundred lighting companies. With all the choices of outside light fixtures available, the "Night-Sky Friendly" designation can be very helpful to consumers.

On a municipal level most towns in southern and central Maine of any size that have streetlights have chosen to purchase their lights from CMP or Versant, rather than rent them. Those towns, including Brunswick, have then converted the fixtures to LEDs, and most with a color temperature rating of 3000K or less. A notable exception was Harpswell that recently converted its streetlights to 2200K. These are very positive developments but there is still more to do regarding new developments in our communities and the upgrade of commercial lighting of buildings and parking lots.

[Slide 40] What can an average person do?

First, let's get our own houses in order by following these five simple guidelines from Dark Sky International:

Number 1**: Use light only when you need it.** Don't leave lights on all night. Better still is to have motion sensors so that the lights only turn on when there is some activity in the area to be lit.

Number 2**: Light only what you need lit**, such as your driveway adjacent to the house or walkways. Don't light the whole outside of your house like a prison yard! Enjoy the stars and remember all those creatures who share your space and who are affected by artificial light at night!

Number 3: **Be mindful of lumen output, not wattage**. Replacing a 150 watt flood light with an LED of 150 watts will generate way too much illumination because of the efficiency of the LED. Look for lumen output. Choose one appropriate to the task at hand. Don't over-light. The human eye is very adaptable and does not have to be flooded with lumens to work well in lower light.**[Show Light bulb Box]**

Number 4: **Choose a warmer color temperature** (lower Kelvin rating), preferably 3000k or lower. Currently, bulbs are available in three color temperatures of 2700°, 3000°and 5000° varieties. But keep checking: manufacturers are introducing bulbs with lower and lower color temperatures as awareness grows.

Number 5: When shopping for new outside fixtures **choose ones with DSI's Fixture Seal of Approval for "dark-sky friendly" fixture design.** Look for full cut-off features that will throw light to the ground, where it is needed. **[Show lamp fixture]**

[Slide 41] Other ways to help: Support DSI and local organizations like Dark Sky Maine in their efforts to educate the public about light pollution and how to reduce it. Dark Sky Maine offers local advocacy and public outreach that celebrates Maine's dark skies.

[Slide 42 and 43] Become knowledgeable about local ordinances. Learn about local ordinances and rules that address outside lighting in your community. With the new C-PACE program, we can make sure local businesses understand good dark-sky-friendly

outdoor lighting choices. We can work to make sure our local ordinances support dark-sky-friendly choices and results. Last year, the Legislature considered a statewide effort to address outside lighting. The bill failed for a number of reasons but the interest is there to see some form of legislation, so stay tuned! Be ready to participate, to submit comments, to write letters to the editor, and to make your voice heard!

[Slide 45] Globe at Night: Become a citizen scientist! An international program called Globe at Night has been operating for the past fifteen years to gather measurements from people all over the world of the limiting visual magnitude of stars they can see from their locations. Using star charts of various magnitudes observers match the chart to what they see. Their observations are then loaded into a database and then compiled into light pollution maps from the ground up. These maps are then used to help calibrate what orbiting satellites reveal of light pollution as seen from space. It takes only 15-20 minutes (mostly to allow your eyes to dark adapt). You then log on to the website and record your results. You can also use a number of free or very inexpensive apps that use your cell phone camera to gather the data that can then be uploaded automatically to the Globe at Night database. **[Show cell phone app]**

[Slide 46] Promote Eco-Tourism! Encourage state officials to take advantage of Maine's ruralness as a selling point for eco-tourism! As noted, we have the largest contiguous area of dark skies east of the Mississippi and we are within a day's drive to tens of millions of fellow Americans who have never seen a truly dark sky. Pennsylvania has done it with Cherry Springs State Park – why not Maine with some of our state parks?

Celebrate **International Dark Sky Week** by taking part in a star party or other event celebrating dark skies. This year the event is April 2-8, 2024, just prior to the Total Solar Eclipse on April 8th!

Conclusion:

Darkness is a valuable resource, but as I hope this talk has illustrated there are many ways in which that resource is being spoiled. Light pollution affects our local environments in countless ways, changing ecosystems that have evolved over millions of years, in ways not yet fully understood – but the signs are there. Light pollution affects our quality of life and the opportunity to experience the majestic, denying the human soul the opportunity to recalibrate. Light pollution can affect our human health in ways that are just beginning to be understood. And light pollution definitely affects our pocketbooks and municipal budgets. Unlike so many problems of our crazy world, this one offers you a way to actually do something yourself. With the flip of a switch we can start in our own backyards with how we use light. We can then move on to our communities to preserve for our children and grandchildren a nighttime environment that allows our fellow creatures on this earth to survive and thrive as they evolved to do, and for us to experience the breathtaking beauty of truly dark skies. We can go from this…. To this…. We do not have to settle for bad lighting! **[Slide 46, 47, 48, 49 and 50]**

I hope you now have a better understanding of this issue including that it is the cumulative impact of our individual choices, and you now know what you can do on your own to make our communities and state "the way life should be" – a place where you can see the stars!

Thank you.

Post Script: **[Slides 51, 52 and 53]** You may have heard recent news stories about plans by Space X, Amazon and others to launch up to 40,000 to 50,000 (or more) low Earth-orbiting satellites the purpose of which is to expand Internet access. These satellites

would be particularly visible in pre-dusk and pre-dawn twilight of magnitudes as bright as 2.5 (similar to most of the stars in the Big Dipper). There was little to no advance discussion with the astronomical community about the effect these satellites would have on visual and radio astronomy. Space X has launched about 4,500 so far. While this development is not light pollution per se it is a form of sky pollution and represents another example of the tragedy of the commons. Southern Maine Astronomers, along with many others, has formally raised our objection to the unbridled proliferation of satellites in our skies. In addition to interfering with visual and radio astronomy research, requiring hours of time to eliminate the effects of satellites streaking through long exposure images of deep sky objects, it also interferes with our own planetary defense, as ground-based observatories search for very faint objects that could pose a hazard to life on Earth were one of them to impact Earth. These dangerous "Near Earth Objects" and "Potentially Hazardous Objects" are very faint, and finding them is disrupted by streaking satellites. Unfortunately, this is our new reality.