Problem Chosen	2023	Team Control Number
E	MCM/ICM Summary Sheet	2318291

In order to best measure light pollution, we consider several factors such as the population density of a region, the average brightness of light sources, and the tendency of those sources to pollute the environment. After compiling data for each of our variables we were able to estimate the light pollution for protected, rural, suburban, and urban areas. We developed an equation that uses the provided variables to find a theoretical value for light pollution.

The first step of our model inputs the previously mentioned variables, and more, and outputs a variable light pollution rating. We gathered relevant data on protected, rural, suburban, and urban areas that allow us to complete a calculation and output a final value representing light pollution for an area.

The second step of our model aims to measure the impact of mitigation techniques. We analyzed our equation and determined that the average brightness of a light source, the percent of light from a source that affects the outdoors, and the maximum intensity of a light source would be the most influential. We then developed mitigation strategies that aimed to influence these variables. After determining how these strategies would influence each variable, we recalculated what the light pollution would be after our strategy was employed. From this, we concluded that establishing “dark sky zones” would be the most effective mitigation strategy for protected areas and applying red window filters would be the most effective mitigation strategy for urban areas.

Measuring and Mitigating Light Pollution

2/16/23

Control #2318291

Contents

1 Introduction

In this paper, we will present a metric used to determine the risk of light pollution in a given location, apply this metric to four different regions, and then present 3 potential mitigation strategies and their predicted effects using our model. In order to create a flexible model, we crafted a metric that primarily depends on population density and light generating infrastructure, providing broader applicability. We then developed mitigation strategies that would reduce the risk levels obtained from our metric. These strategies consider both human and non-human factors, and can be implemented in specific areas to help reduce the risk and damage light pollution causes.

1.1 Outline of Our Approach

The beginning of our paper will be devoted to building our metric. We will explain the data behind our reasoning and piece each part together to build a final equation that outputs *L*, the risk of light pollution. The later sections of our paper are dedicated to developing mitigation strategies and applying them.

- **Create the metric** for determining risk of light pollution.
- **Apply the metric** to four distinct regions to gauge the risk of light pollution. These regions include, Protected Land, Rural, Suburban, and Urban.
- **Identify mitigation strategies** that will reduce the risk of light pollution based on our metric.
- **Apply the strategies** and analyze their effect to see how it changes the output of our metric.

1.2 Terminology

- Light Pollution is the alteration of light levels in the outdoor environment due to man-made sources of light [5].
- A "building" is an edifice with more than 2 above ground floors.
- A "house" is an edifice with 1 or 2 above ground floors.
- Any "light source" in our paper will refer to one of three types of light producers; a building, a house, or a street light.
- The word "light" by itself will refer to an individual light bulb found inside of a light source.

1.3 Assumptions

- An "urban" region has a population density of $400 < \rho_U < 5000$ persons per square kilometer.
- A "suburban" region has a population density of $100 < \rho_{SU} < 400$ persons per square kilometer.
- A "rural" region has a population density of $1 < \rho_R < 100$ persons per square kilometer.
- "Protected land" has a population density of $0 < \rho_P < 1$ person per square kilometer.
- Street lights use 90 Watts of power [6].
- House and building lights use 60 Watts of power.
- "Night time", for the purposes of this paper, will begin at 8 PM and end at 8 AM.
- All building lights, house lights, and street lights shine with a frequency of 440 nm, standard white LED light frequency [4,9].

2 Light Pollution Breakdown

Light pollution can be caused by a variety of factors depending on the region. For instance, an urban environment would have lots of light pollution from billboards or advertising while a rural environment would find much of its light pollution coming from houses. We have approximated breakdowns of the types of lights in the four different environments, shown in the table below.

Building lights encompass all light escaping from windows, walls, and roofs of buildings.

House lights encompass all light escaping from windows, roofs, and outsides of houses.

Street lights encompass a variety of outdoor lighting including street lamps, billboards, and other facade lighting from businesses that might affect the street.

TABLE 1	Building lights ℓ_b	House lights ℓ_h	Street lights ℓ_s
Protected	0%	20%*	80%
Rural	0%	90%	10%
Suburban	10%	20%	70%
Urban	8%	2%	90%

* To clarify, it wouldn’t make sense for houses to exist in a protected area. But, it does make sense for there to be multiple 1 or 2 story buildings, which we define as a “house.”

After considering this data, it would make sense to derive mitigation strategies that target the largest highest percentage for a certain region. To decide what mitigation strategies to employ, we must first consider what variables must be minimized.

3 Assessing Light Pollution Risk

The following sections may be difficult to interpret, so in this section we will define and clarify some of our notation.

All subscripts of "i" refer to a type of light source, either "b" for "building", "h" for "house", or "s" for "street". For example, N_i refers to the number of lights per light source i. Furthermore, N_b would represent the number of lights per building, N_h would represent the number of lights per house, and N_s would represent the number of lights per street light (which is always 1 for street lights).

Similarly, all subscripts of "reg" refer to a type of region, "P" for "protected land", "R" for "rural", "SU" for "suburban", and "U" for "urban". L_{reg}, for example, refers to the light pollution risk rating for a certain region, while L_{SU} refers specifically to the light pollution risk rating of a suburban area.

To measure a region's light pollution, we first created a list of all potential factors that would influence the risk of light pollution in an area. From this list, we eliminated variables that did not majorly affect light pollution. The below table defines each of the primary factors of light pollution.

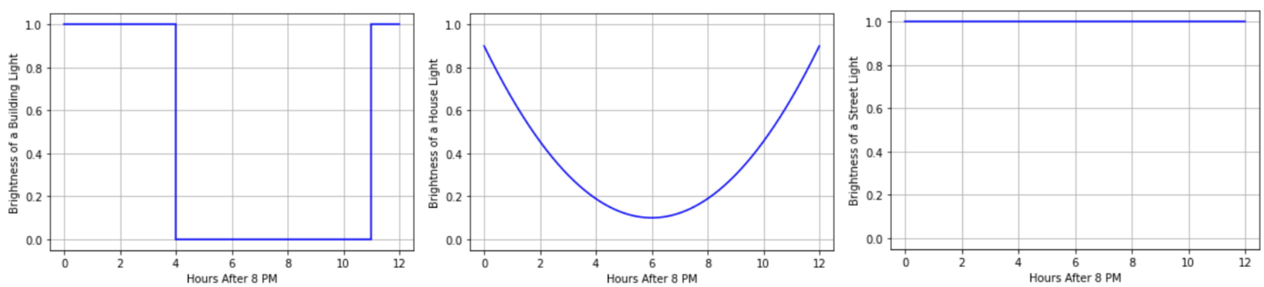
TABLE 2	Definitions
R_{reg}	Rate of pollution of a specific region. R_{reg} is mostly dependent on the ratio of building lights to house lights to street lights found in Table 1 above.
S_i	Rate of pollution of a specific light source, i. ($i = b, h$, or s)
N_i	Number of lights per source, i.
ε_i	Efficiency of pollution of a light source, i.
χ_i	Percent of lights per source, i, that affects the outdoors.
U_i	Percent of escaping light that radiates above the horizontal from a source, i.
D_i	Percent of escaping light that radiates below the horizontal from a source, i.
r_i	Percent of D_i that reflects off of the ground, back into the atmosphere.
$B_i(t)$	The relative brightness of a light source, i, as a function of time from $t = 0$ to $t = 12$. $t = 0$ corresponds to 8 AM $t = 12$ corresponds to 8 PM $B_i(t)$ takes into account that some lights are dimmable lights, and will have a value of: 1 if a light of type i is undimmed 0 if it is off Any number in between if it is dimmed.
M_i	The maximum possible Intensity of a light of type i. M_i is a function of the *power* of an individual light, as well as its *wavelength*. This will be further clarified later.
ρ_{reg}	The population density of a specific region in $people/km^2$.

In the next section we will piece together these variables into minor equations which can then be built into our final Light Pollution Rating Equation (LPRE). In section 4 we input data from protected, rural, suburban, and urban areas into our equation and have a final light pollution rating for that region.

3.1 Brightness Function

In sections 3.1 and 3.2 we will further explain the variables and how they fit together to build a larger equation.

First, we begin by defining $B_i(t)$, the brightness for each type of light source.



These graphs represent the estimated brightness of a light source overnight.

We estimate that a typical building light will be on until midnight at full brightness ($B_b(t) = 1$ for $0 \leq t < 4$), before turning off for the night ($B_b(t) = 0$ for $4 \leq t < 11$), until finally coming back on at 7 AM and staying on at full brightness ($B_b(t) = 1$ for $11 \leq t \leq 12$).

We modeled $B_h(t)$ with a parabolic curve with a minimum of 0.1 at $t = 6$ (2 AM) to capture the idea that generally there are less and less house lights on from 8 PM to 2 AM due to most families going to bed. $B_h(t)$ then increases after 2 AM to a maximum of 0.9, insinuating that most families have woken up by about 8 AM.

The decision to model $B_s(t)$ as 1 through the whole night, comes from the fact that street lights remain illuminated from dusk to dawn in most areas.

3.2 Average Brightness and Efficiency

Now that $B_i(t)$ is well understood, we can move on to defining a new quantity, $B_{avg,i}$,the average brightness of an individual light of type i overnight.

This value can be calculated by applying the average value formula, $\frac{1}{b-a}\int_a^b f(t)dt$, on the function $B_i(t)$ from $t = 0$ to $t = 12$, yielding

$$B_{avg,\, i} = \frac{1}{12}\int_0^{12} B_i(t)dt$$

With $B_{avg,i}$ understood, we now move on to a new variable, ε_i, a metric that describes the efficiency of an individual light of type i. ε_i is defined as the following: $\varepsilon_i = \chi_i B_{avg,\, i} M_i (U_i + D_i r_i)$

Notice the $(U_i + D_i r_i)$ term, which encapsulates all of the escaping light that will end up in the atmosphere, as well as the dependency on χ_i, $B_{avg,i}$, and M_i, and how if any of these terms increase, so too should the efficiency of light pollution of that light, ε_i.

3.3 Rate of Pollution

With ε_i calculated we can now calculate S_i, the rate of pollution of a light source, with the formula

$$S_i = N_i \varepsilon_i$$

Recall that ε_i described how efficiently an individual light was polluting, so all that has been done here is to multiply that efficiency by the number of those lights that appear in each type of light source.

We are now equipped to calculate R_{reg}, the rate of pollution of a region, with the formula: $R_{reg} = \ell_{reg,b} S_b + \ell_{reg,h} S_h + \ell_{reg,s} S_s$, which appropriately combines the rate of pollution of each of three types of light sources (S_i) with how prevalent they are in each region ($\ell_{reg,i}$)

The formula can be compacted into:

$$R_{reg} = \sum_i (\ell_{reg,i} S_i)$$

3.4 Simple and Final LPRE

Finally, after recognizing that the light pollution rating L for any region should be proportional to its population density as well as the rate at which its light sources are polluting, we can relate L with ρ and R with the formula:

$$L_{reg} = \rho_{reg} R_{reg}$$

This “simple” version of the LPRE is rather constrained, though. It can only calculate an L value for a region with a single defined value for ρ and R. Considering that not all suburban regions, for example, have the same ρ or R value, we would like an equation that averages the simple LPRE value over all possible ρ and R values defined for a particular region like “suburban”. Treating the simple LPRE as a function of ρ and R and averaging $L(\rho, R)$ over all of ρ and R using the average value equation for a function of two variables, $\frac{1}{A}\iint_{\mathcal{D}} f(x,y)\,\mathrm{d}A$

where D is the region encompassed by all possible ρ and R values, A is the area within the region D, and $f(x, y)$ is $L(\rho, R)$, yields the final LPRE equation,

$$L_{avg,reg} = \frac{C}{(\rho_{max} - \rho_{min})(R_{max} - R_{min})} \int_{\rho_{min}}^{\rho_{max}} \int_{R_{min}}^{R_{max}} (\rho R)\, d\rho\, dR$$

ρ_{min}, ρ_{max}, R_{min}, and R_{max} describe the minimum and maximum values for ρ and R associated with a particular region respectively, while C is an arbitrary scaling constant that has been included to make our numbers a bit nicer. We will take C to equal 2.749

4 Applying the LPRE

Now that we understand what variables affect light pollution for a region, we can use general data from each region to calculate L. Data that could not be sourced was estimated. The following table represent values for our variables:

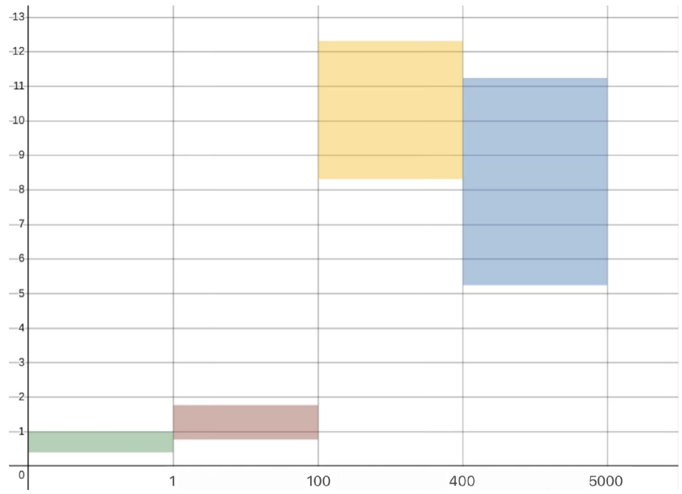
TABLE 3	N	χ	M	U	D	r
Building	1500[12]	.4	.66	.3	.7	.4[13]
House	67[12]	.2	.66	.3	.7	.22[13]
Street	1	1	1	.5[4]	.5[4]	.075[13]

As a reminder, ℓ_i refers to the percentage of lights in the given area that are of type i. The following table reiterates the ℓ_i values:

TABLE 1	Building lights ℓ_b	House lights ℓ_h	Street lights ℓ_s
Protected	0%	20%	80%
Rural	0%	90%	10%
Suburban	10%	20%	70%
Urban	8%	2%	90%

R values were calculated for each of the four regions and then *smudged* into a potential range of values, since not all region types will have the same distribution of building, house, and street lights.

The following chart depicts the ranges of Light Pollution that fall within the four regions, Protected (Green), Rural (Red), Suburban (Yellow), Urban (Blue).

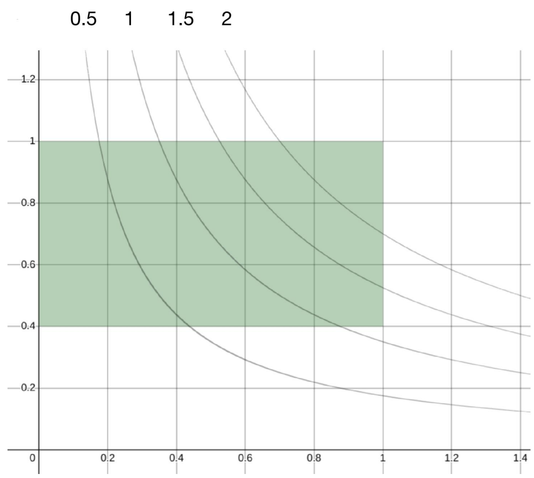


Combined Ranges of Regional LPRE Values
x-axis: ρ
y-axis: R values (computed with the simple LPRE)

In the series of charts in the following sections, the curved lines represent every combination of ρ and R that yield a value corresponding to the number at the top. Each x-axis is population density and each y-axis is R values.

4.1 Protected Areas

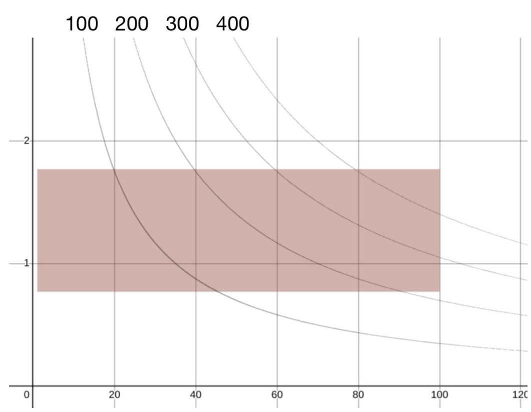
After computing $L_{avg,P}$, the final LPRE value for protected land areas P, and thanks to the aforementioned arbitrary scaling constant C, we conclude that protected land areas have, on average, an LPRE value of 1.00



Protected Area LPRE Rating (Avg: 1.00)

4.2 Rural Areas

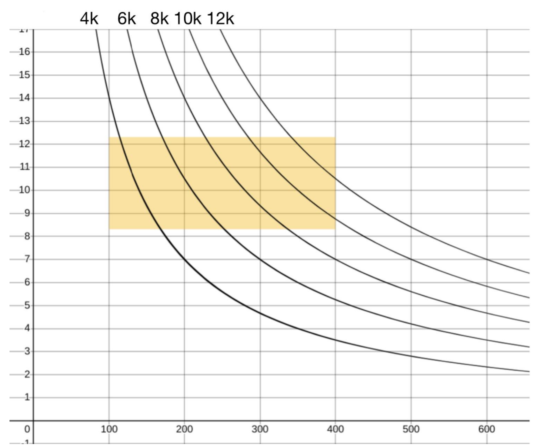
After inputting each variable from the rural area data set, we can conclude that the light pollution rating is 193.29. This can be interpreted as “a rural area pollutes 193.29 times more than a protected area.”



Rural Area LPRE Rating (Avg: 193)

4.3 Suburban Areas

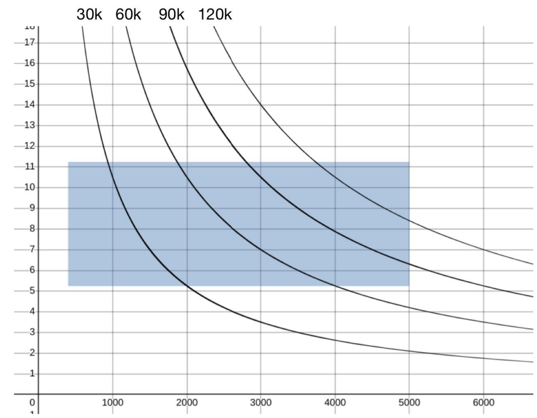
After inputting each variable from the suburban data set, we can conclude that the light pollution rating is 7107.538. This can be interpreted as "a suburban area pollutes 7107.538 times more than a protected area" or "a suburban area pollutes 36.77 times more than a rural area."



Suburban Area LPRE Rating (Avg: 7110)

4.4 Urban Areas

After inputting each variable from the urban area data set, we can conclude that the light pollution rating is 61220.244. This can be interpreted as "an urban area pollutes 61220.244 times more than a protected area," "an urban area pollutes 316.727 times more than a rural area," or "an urban area pollutes 8.613 times more than a suburban area."



Urban Area LPRE Rating (Avg: 61,200)

5 Mitigation Strategies

After analyzing our model, we determined that $B_i(t)$, χ, $and\ M_i$ would be the values most subject to change through possible human influence. By choosing to develop strategies aimed at reducing these values, our solutions become more viable and realistic. The following sections will provide a description of each strategy, how it interacts with our model, and the effects of applying our strategies on light pollution.

5.1 Designating dark sky zones

One way to reduce light pollution in public areas such as national parks or large regions of public land is to establish a "dark sky zone." This refers to an area where the use of lighting is heavily regulated or prohibited outright with the goal of limiting sky glow and optimizing visibility of the stars. The International Dark Sky Association, an organization formed to reduce light pollution, aims to increase the number of dark sky zones in order to preserve the night sky [11].

If a dark sky zone were to be instituted, it would affect our metric drastically in multiple ways. The primary being that the Brightness function, $B_i(t)$, would drop to 0.

The creation of dark sky zones throughout the world has been one of the driving forces for increasing the visibility of the night sky. It makes the most sense to dedicate rural or protected areas as dark sky zones, as the initial light pollution tends to be lower in these locations and visibility of the stars is more easily achievable [11]. Establishing a dark sky zone in an urban environment presents a host of problems, and would inconvenience human activity. But for a rural or protected area, the changes necessary to make a region a dark sky zone are less drastic and come at a far lesser cost [11]. By establishing a dark sky zone in these less populated regions, human activity isn't interrupted as significantly and the effects of light pollution in these areas will be reduced.

5.2 Reducing light intensity

Reducing light intensity can be achieved two ways: color moderation, and light curfews. Color moderation relies on reducing M_i, as the maximum intensity of the light can be reduced by increasing the wavelength [2]. This can be seen from combining the equations for light intensity, power, and energy, featured below.

$$M = \frac{P}{A} \Rightarrow P = \frac{E}{s} \Rightarrow E = \frac{h \cdot c}{\lambda \cdot s} \Rightarrow M = \frac{h \cdot c}{\lambda \cdot s \cdot A}$$

We also incorporated two ratios, one derived from the average LED White Light wavelength of 440 nm, and the other derived from the average power consumption of an LED streetlight of 90W [4,9]. By combining these values, we are able to assign ratios that that provides the following relationships:

$$M_i \propto \frac{440}{\lambda}$$

$$M_i \propto \frac{W}{90}$$

$$M_i = \frac{440}{\lambda} \cdot \frac{W}{90}$$

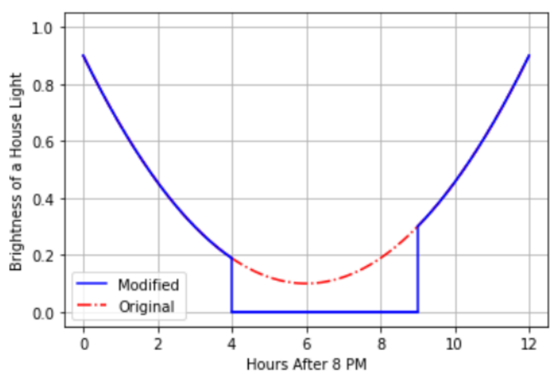
As the area and time we are measuring will not change, the only variable that can reduce the intensity of light M is the wavelength. Humans perceive changes in wavelength as changes in color, ranging from red (700 nm) to violet (380 nm) [9]. Most of the light generated by society is white light, which usually has a wavelength of 440 nm [9]. We propose a filter that can be applied to the exterior of windows that raises the wavelength of escaping light and thus reduces the intensity [1]. By applying this filter, we predict the light intensity M, will be reduced and the overall light pollution will be reduced. Applying these changes to our metric results in the following:

$$M_I = \frac{440}{700} \cdot \frac{60}{90} = 0.419$$

This shows that if red filters were applied, we would see an approximate drop in light intensity of 61% when compared to that of a street light.

The secondary means of light intensity reduction is to institute light curfews [7]. By constructing mandatory times where houses and buildings must turn off or shield the light they produce from escaping, the light escaping and intensity of the light would be reduced. Specifically, we suggest a curfew starting at 12 pm and lasting until 5 am. We believe this time frame will be the least impactful to regular human activity, while still reducing light intensity throughout the night. The purpose of this curfew is to restrict the amount of light "escaping" after dusk, meaning we believe the primary impacts will be seen in (χ). However we also expect a slight change to appear in the function $B_i(t)$ as the average time of lights being on is in essence being capped. We predict (χ) to decrease by a factor of 20, following guidelines published by the USA DOE [8]. Applying this strategy to our model results in the following:

$$\chi \Rightarrow \frac{\chi}{20}$$



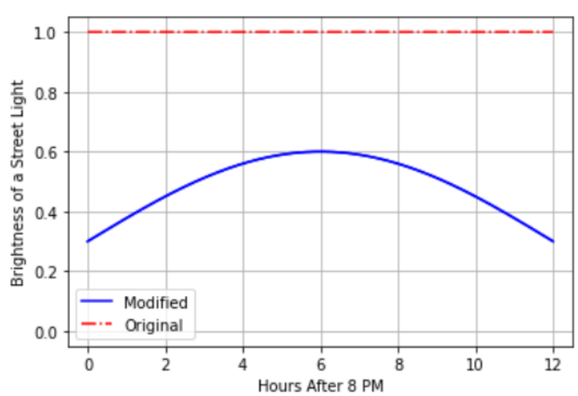
While these techniques will reduce the amount of light pollution, these strategies also place a large responsibility on houses and businesses to abide by these programs/curfews, potentially impacting the reliability and efficacy of our models predictions. Other effects specific to these strategies include potential disturbances to wildlife from unnatural exposure to colored light. However, according to a study from Norway, red light has proven to be the least harmful (and impactful in general) [10]. Data was collected on the effects white, blue, green and red light had on insects, bats, birds, and rodents, and it found that while any artificial light at all was harmful to the local fauna, red light was the least impactful [10]. This study adds weight to the idea that our color moderation proposal would both decrease light pollution (through intensity) and begin to directly combat the effects of light pollution on wildlife. With regard to light curfews, the main problem lies solely in enforcement, as the weight of this policy falls on the shoulders of the citizens and business owners.

5.3 Upgrading light generating infrastructure

Current light infrastructure, mainly street lamps, are widely regarded as the primary cause of light pollution in urban regions [3]. Street lamps, billboards, and outdoor advertisements are on 24/7, and typically lack shielding of any kind. If we can reduce their impact, we predict we will see positive change towards light pollution and its ecological effects.

In 2017, the city of Tucson, Arizona conducted a study to better understand the effects of street lighting on light pollution. The city decided to change the type of bulbs in their street lamps and also decrease the light brightness during low traffic periods overnight. After installing LED bulbs in the roughly 20,000 street lamps across the city, researchers dimmed the bulbs to 30% brightness from midnight until the lights were shut off after dawn. It is important to note that street lamps near crosswalks remained running at 90% due to safety concerns. After proceeding with the dimming measures for 6 days, researchers measured a shift in the contribution of street lighting. Before, street lamps had contributed roughly 18% to light pollution. By systematically dimming the lights, this was brought down to 13% [6].

By applying this dimming concept to LED billboards and street lamps, it is clear that this method can provide effective change. Based on the assumption that lights should be generally brighter when it is darkest, to account for safety concerns, we modeled the following curve. We reduced the peak light brightness to 60%, and scaled the dusk and dawn levels at 30%. The following adjusted graph of $B(t)$ is provided:



After implementing this strategy of dimming lights, $B(t)$ has a new average brightness of 0.49, as compared to 1.

Dimming street lighting would also positively affect the local ecosystem, as a study performed across Europe found that artificial light has an effect on all levels of biological organization, from cell to ecosystem [8]. Circadian patterns, reproduction rates, crop yields, and migration patterns were all affected by artificial light [8]. This study also shows a clear correlation between brightness of light and magnitude of impact, showing that organisms experience serious changes when experiencing high brightness (X>15 Lux). In Tucson, AZ the street lights at 100% brightness were measured at 9.8 Lux, and when reduced operated at below 3 Lux [6]. This would drastically reduce the risk towards animals and result in minimized effects.

While there are studies that support the positive effects of dimming street lights, many remain concerned about an increase in crime. However, the presence of street lights has no effect on crime. Turning street lights off entirely, on timers, dimming them, and on entirely, showed no relationship with crime or the number of vehicle collisions [11]. So while street lights do not specifically impact the safety of an area, they do still generate a feeling of safety within a community [11]. Because of this, we believe a timed dimming of street lights to between 60% and 30% brightness will create the largest impact on light pollution while facing the least public resistance.

6 Applying Mitigation Strategies

In this section we will input our previously gathered data for urban and protected areas before any light pollution mitigation strategies are employed, and then apply them and see how much each strategy would theoretically affect both regions. From this we can then analyze and choose the best strategy to apply to the urban and protected areas.

6.1 Applying to Protected Areas

The unmitigated light pollution of a protected area is estimated to be 1 by our metric.

- By instituting a dark sky zone in a protected area, the brightness of the lights $B(t)$ goes to 0 and thus the light pollution goes to 0. While initially nonsensical, this does align logically as a dark sky zone would simply be a totally 'light-less' area at night. The mitigated light pollution is then estimated to be 0.
- By applying red filters to windows in order to reduce light brightness in a protected area, the M_i will drop to 0.41, as opposed to 0.667.

The mitigated light pollution is then estimated to be 0.848.
- By upgrading light generating infrastructure in an urban area, so that it dims with time, altering the $B_{avg,i}$, the new $B_{avg,i}$ would be 0.491. The mitigated light pollution is then estimated to be 0.699.

From these results we can deduce that instituting a dark sky zone would be the most effective method of light pollution mitigation for protected areas.

6.2 Applying to Urban Areas

The unmitigated light pollution of an urban area is estimated to be 61,220 by our metric.

- By instituting a dark sky zone in an urban area, the brightness $B_i(t)$ would go to 0, meaning there is no light being produced at night. In the Urban case, this solution is clearly not feasible, but the mitigated light pollution is still estimated to be 0.
- By applying red filters to windows in order to reduce light brightness in an urban area, the M_i will drop to 0.41, as opposed to 0.667. The mitigated light pollution is then estimated to be 39,815.
- By upgrading light generating infrastructure in an urban area, so that it dims with time, altering the $B_{avg,i}$, the new $B_{avg,i}$ would be 0.491. The mitigated light pollution is then estimated to be 59,392.

It is important to understand that while instituting a dark sky zone in an urban area would be incredibly effective for mitigating light pollution, it is not feasible. This would impact human activity too sharply. With this in mind, we can analyze these results and deduce that the red window filter strategy would be the most effective method of light pollution mitigation for urban areas.

7 Improving the Model

This section will include discussion on the strengths and weaknesses of our model, as well as a few ideas that would improve our model moving forward.

7.1 Strengths

Our model was designed with the intention of it being very general. This was in order to ensure the versatility and applicability of our model to various regions.

After collecting a handful of variables from a region, our model can estimate the light pollution relatively easily. Other methods of determining light pollution require experimental data, while our model allows calculations to be done without light pollution tools such as a Sky Quality Meter, the most commonly used tool for data collection. The breadth of variables our model encompasses also produces a secondary strength beyond general applicability: gauging the effectiveness of new ideas. All of the previously mentioned studies relied on physical experimentation to determine new ways of reducing light pollution, which can involve extensive funding, laborious implementation, and long periods of time before any actual effect can be seen. With our model, if the proper preliminary research is done, it can generate an estimated effect tailored specifically to the region in question. City councils looking to reduce their light pollution without the budget to invest in a major change can instead fund preliminary research into what type of mitigation strategies would work best for their specific area.

7.2 Weaknesses

While our model's greatest strength is its versatility and inclusion of a multitude of variables, this is also a source of weakness. Due to the broadness of the metric, our model does lose a degree of accuracy. We remedy this by intaking demographics specific to the region the model is being applied to, but without truly knowing the exact values for every variable of a given region our model cannot be entirely accurate. The numerous variables also lend themselves to complexity, which can distract and potentially confuse those who may use our model. However, we believe that the incorporation of so many variables allows users a greater chance to input the information about the area they do have, and thus cancel out the inaccuracies that may rise from such a generalized model.

7.3 Improvements

The model can be improved in several ways, with the first being actual experimental data. While studies and reports were consulted, these resulted in ranges of values, meaning that if the specifics of a city were known our model could produce a more accurate representation of what the light pollution risk in that area would be. This in turn would also create more accurate and valuable data on how potential strategies would affect light pollution. Our model could also be improved with the inclusion of the metric that measures energy availability and consumption per capita. This would allow our model to account for more definitions of the four different regions. By incorporating a variable responsible for energy consumption our model could examine the differences between areas with different amounts of power/industrialization even if they have the same population. Overall this would strengthen the applicability of our model and allow us to better consider different regions.

8 Conclusion

Defining and calculating the risk of light pollution for a specific area has proven to be quite involved, requiring input and data from a dozen different areas of study. For each of the four distinct regions, our model was applied and produced a baseline output regarding the light pollution risk from that area. By running different mitigation strategies through our model, we were able to deduce what types of policies, and initiatives would prove most helpful in reducing light pollution and its harmful effects on the environment. We gave specific consideration to Protected regions (deemed the most important area to prevent light pollution) and Urban regions (the highest producer of light pollution), by analyzing which of our potential mitigation strategies would result in the greatest reduction in light pollution in these areas.

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