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DOI

[10.1080/21550085.2017.1374010](https://doi.org/10.1080/21550085.2017.1374010)

Publication date

2017

Document Version

Final published version

Published in

Ethics, Policy & Environment

Citation (APA)

Stone, T. (2017). Light pollution: A case study in framing an environmental problem . *Ethics, Policy & Environment*, 20(3), 1-28. <https://doi.org/10.1080/21550085.2017.1374010>

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Light Pollution: A Case Study in Framing an Environmental Problem

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ABSTRACT

Light pollution is a topic gaining importance and acceptance in environmental discourse. This concept provides a framework for categorizing the adverse effects of nighttime lighting, which advocacy groups and regulatory efforts are increasingly utilizing. However, the ethical significance of the concept has, thus far, received little critical reflection. In this paper, I analyze the moral implications of framing issues in nighttime lighting via the concept of light pollution. First, the moral and political importance of problem framing is discussed. Next, the origins and contemporary understandings of light pollution are presented. Finally, the normative limitations and practical ambiguities of light pollution are discussed, with the aim of strengthening the framework through which decisions about urban nighttime lighting strategies are increasingly approached.

KEYWORDS

Light pollution; nighttime lighting; night sky; darkness; problem framing

Introduction

I have outwalked the furthest city light, ends the first stanza of Robert Frost's poem 'Acquainted with the Night'. For many contemporary urban dwellers, such a feat is becoming exceedingly difficult in our electrified, 24 h societies. While artificial nighttime illumination has brought with it many advances and possibilities, the negative consequences of its ubiquity and proliferation have only recently emerged as a topic of inquiry. Discourse is increasingly framing concerns about nighttime lighting via the concept of *light pollution*, particularly with respect to environmental effects. However, light pollution has received relatively little attention compared to other environmental problems, remaining scientifically and culturally 'in the dark' (Hölker et al., 2010). Equally important, the framing of environmental problems caused by artificial nighttime lighting via the concept of light pollution has received little critical attention. Understandings of light pollution are reliant on seemingly technical descriptions—light pollution is used to categorize and quantify the adverse effects of artificial nighttime illumination. But such a categorization carries an implicit normative judgment, and should not be accepted without critical reflection.

The purpose of this paper is to elucidate light pollution as a normative concept, and focus specifically on its increasing role in shaping, or framing, future regulatory efforts, and

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decision-making processes. The goal is not to condemn or approve of the use of light pollution from an ethical perspective, nor is it to arrive at definitive answers for the ambiguities inherent in the concept. Rather, I begin by accepting the term as the dominant concept for describing a novel environmental problem, and critically reflect on its ethical significance and potential limitations. While the implications of light pollution are far-reaching, here I will focus specifically on light pollution as it relates to urban nighttime lighting. Such an analysis can be seen as an example of an issue discussed within this journal by Elliott (2009), namely the ethical significance of language and terminology choices for framing environmental policy decisions and debates. While Elliott discusses very different types of pollution, the themes highlighted are quite relevant for an examination of light pollution. Elliott—who draws from a more pragmatic branch of environmental ethics that I adopt here—describes the usefulness of practical ethics for policy discussions. Philosophers can help to create and define the moral space within which policy decisions will be made, and so can contribute to upstream policy decisions. Elliot (2009, p. 170) explains that,

Rather than attempting to develop controversial theoretical conclusions about debated environmental issues, scholarship of this sort elucidates ethically significant questions and promotes critical reflection, shared understanding, and informed decision making in response to them. This sort of work could also incorporate attempts to clarify how particular linguistic frames affect the attitudes of public groups toward environmental initiatives.

Thus, this paper will help to define the moral parameters within which decisions on nighttime lighting regulation are housed, and will highlight critical questions that require further exploration alongside light pollution's 'downstream' use in political decision-making.

Section 2 discusses the moral and political significance of framing problems, in relation to the novel environmental problem of excess artificial nighttime lighting in cities. Section 3 then analyzes the concept of light pollution in detail. Here, both the origins of the concept and its current manifestations are presented, in order to provide a more comprehensive understanding of light pollution. Section 4 returns to the question of how light pollution frames concerns and possible responses, and discusses two interrelated questions: the potential limitations of the concept as a normative or prescriptive tool, and the ambiguities and inconsistencies in its practical application that require clarification. Thus, first steps are taken in dissecting the ethical significance of the concept of light pollution and the role it can play in addressing the adverse effects of artificial nighttime lighting.

Framing a New Environmental Problem

We are faced with a new problem: simply put, we have *too much light at night*. For centuries, more and better urban nighttime lighting was largely seen as desirable and necessary. However, following the rapid proliferation of electric lighting throughout the twentieth century, the impacts of artificial nighttime illumination have become a research interest—or rather concern—in a variety of disciplines. Nighttime lighting uses enormous amounts of energy, in addition to costing billions of dollars, damaging ecosystems, and negatively affecting human health.¹ With this emerging knowledge, continuing with the same use patterns and regulatory strategies can no longer be justified. We must rethink our urban nights. But, some amount of artificial light is, of course, still desirable and necessary at night. Therefore, our new problem comes with a novel question: *how much artificial light at night is appropriate?*

Such a question may not strike you as entirely novel or revolutionary, as surely such questions are as old as attempts to illuminate our nights. But, the context in which this question is posed—the growing recognition of environmental and health-related problems caused or amplified by nighttime lighting—gives it new meaning. We are now seeking a transition in nighttime lighting strategies toward reducing the amount of illumination. And, it has been acknowledged that traditional approaches have been ineffective to date. Kyba, Hänel, and Hölker (2014) note that despite improvements to efficiency in lighting technologies, energy usage for outdoor lighting and artificial nighttime brightness continues to increase annually. Thus, a complete conversion to efficient lighting technologies alone (i.e. LEDs) is unlikely to reduce energy consumption or other unwanted consequences; new approaches to nighttime lighting must look beyond the narrow focus of improving efficiency. They summarize this necessary change in perspective by stating that,

The challenge faced by 21st century policymakers is to provide outdoor light where and when it is needed while reducing costs, improving visibility, and minimizing any adverse effects on plants, animals, and humans caused through exposure to unnatural levels of light at night. (Kyba et al., 2014, p. 1807)

In other words, we need to frame the problem in a new way.

Light pollution has emerged as the widely accepted term for the negative or adverse effects of artificial nighttime illumination (Hölker et al., 2010). A central assumption of this paper is that the concept of light pollution—due to its increasing usage within professional, academic, and popular discourse—will substantially shape decisions about how to illuminate cities in the twenty-first century. In this role, it will actively inform the conditions for morally acceptable and desirable artificial nighttime illumination. Thus, to a large extent the concept of light pollution helps to provide a framing that addresses our new problem. This, however, necessitates an evaluation of the concept's usefulness—its strengths and limitations. Its increasing usage must be coupled with critical reflection, if it is to offer an effective framing for ongoing policy efforts. In *Policy Paradox*, Stone (2002) discusses the complex issue of defining problems within political discourse. It is never an objective statement, but rather a strategic representation from one point of view that will promote a certain course of action. While problem definitions can act as a '... vehicle for expressing moral values ... there is no universal technical language of problem definition that yields morally correct answers' (p. 134). Nonetheless, focusing on how a problem is defined can help us see the situation from multiple perspectives and identify assumptions about facts and values embedded therein (Stone, 2002). This can, in turn, help to strengthen the problem definition.

With our novel question in mind, we must then ask how the concept of light pollution frames current challenges and associated ethical questions, and what actions it will guide us toward. However, it is pertinent to first clarify the notion of 'framing'. Here, I use the term broadly to describe the conceptual lens through which problems will be defined and perceived, and through which solutions will be posed. Frames are helpful in crystallizing and formulating a problem, but in doing so also set the boundaries of possibility on potential solutions. In *Frame Innovation* (2015), Dorst explains a method of design thinking used to overcome seemingly intractable real-world problems, dubbed the 'frame creation model'. Building on the linguistic research of Lakoff and Johnson (1980), Dorst explains that frames may be simple phrases, but in reality are subtle and complex thought tools. 'Proposing a frame includes the use of certain concepts, which are assigned significance and meaning. These concepts are not neutral at all: they will steer explorations and perceptions in the

process of creation' (2015, p. 63). A good frame should be inspiring, original, robust, and create a common space for finding solutions. And once accepted, a frame will define the parameters of possibility. 'Once frames are accepted, they become the context for routine behavior: once accepted, the frame immediately begins to fade. Statements that started life as original frames become limiting rationalities in themselves, holding back new developments' (Dorst, 2015, p. 65).

Creating a coherent and effective frame for the challenges of nighttime lighting carries its own idiosyncratic considerations. Beyond functionality, the symbolic meanings of lighting technologies have played an active role in determining their uses and acceptance (Nye, 2006). Throughout history, perceptions of nighttime lighting have consistently blurred the literal and the symbolic; intertwined actual lighting with metaphorical notions of the values that lighting embodies (Schivelbusch, 1988). This is not entirely surprising, as metaphors are pervasive in our everyday language (Lakoff & Johnson, 1980) and politics (Stone, 2002). A metaphorical concept allows us to see one thing in terms of another—in this case, to see some outputs of artificial lighting as a 'pollutant' of the night sky, our bodies, and ecosystems. Like sound pollution, it is a powerful framing that will shape how we think, speak, and act with regards to nighttime lighting technologies. Conceptual metaphors are useful but also can be troublesome, because

the very systematicity that allows us to comprehend one aspect of a concept in terms of another will necessarily hide other aspects of the concept. In allowing us to focus on one aspect of a concept, a metaphorical concept can keep us from focusing on other aspects of the concept that are inconsistent with that metaphor. (Lakoff & Johnson, 1980, p. 10)

We need to ask what is highlighted and what is omitted with the light pollution, when considered as a frame.

Central to Dorst's frame creation model (2015) is the great length that designers go to assess the frameworks through which problems are approached. Complex problems—such as the impacts of artificial nighttime lighting—are often caused by underlying value conflicts, and the inability of current frameworks to adequately address said values. By looking into the origins and history of the problem, the key driving issue, and the current context, a more comprehensive picture of the problem and underlying values emerge. And simultaneously the possibility of new approaches, or frames, will also emerge (Dorst, 2015). However, for our present purposes we will not search for a new or radically different approach, but rather ask how the coalescing frame of light pollution is responding to our problem. We have our core issue present in the novel challenge described above. The next steps are to examine the origins and current context in turn, so see how light pollution can be improved as an effective frame.

The Past and Present of Light Pollution

For a comprehensive understanding of light pollution, contemporary discourse must be coupled with an exploration of the origins and emergence of the concept, which in turn requires a broad understanding of the development of urban nighttime lighting. Detailed historical studies into the technological innovations and social implications of artificial nighttime lighting have been published in the past few decades (e.g. Bowers, 1998; Ekirch, 2005; Isenstadt, Maile Petty, & Neumann, 2014; Nye, 1990; Schivelbusch, 1988). And, important studies on the social, economic, and legal aspects of nighttime lighting have also been

published recently (e.g. Meier, Hasenöhrl, Krause, & Pottharst, 2014). The brief discussion below cannot do full justice to the in-depth explorations of nighttime lighting that these scholars have explored, nor to the various cultural and geographical nuances of historical developments in lighting. Rather, I would like to highlight the conditions within which light pollution arose, which puts us in a better position to assess our contemporary definition and ask how the framing of light pollution responds to the core problem discussed above. In particular, Sections 3.1 and 3.2 will highlight the shift away from how to light cities and, somewhat paradoxically, toward a desire for dark or natural nights. Put otherwise,

So while the fascination and allure of illuminations persist, darkness is today increasingly perceived as a rare and valuable commodity. This development could be regarded as a double paradigm shift from the dark night as a forbidding everyday occurrence that could only be lit up sporadically to its devaluation as an emblem of backwardness in the face of a new abundance of artificial light in the late 19th and early 20th centuries to its present valorization as a sought-after luxury in our densely populated and highly electrified world. (Hasenöhrl, 2014, p. 119)

This progression will lead us toward contemporary understandings of the adverse causes and effects of artificial nighttime lighting, discussed in Section 3.3.

The History of Public Urban Nighttime Illumination

Histories of nighttime illumination mainly focus on the seventeenth century onward, for a few reasons. First, lighting technologies remained essentially unchanged for thousands of years before then (Schivelbusch, 1988). Second and relatedly, *public* lighting in the modern sense only emerged in the mid-1600s. This was a time of societal changes in Europe that allowed for lighting technologies and associated urban behaviors to rapidly develop.² In considering the origins of public nighttime lighting in the seventeenth and eighteenth centuries, two important points should be noted. The first is that, despite technical improvements to oil lamps, lighting was still poor and city streets were mostly dark; only major thoroughfares were lit, and often only on the darkest nights of winter for a few hours (Ekirch, 2005; Schivelbusch, 1988). Second, old habits did not die easily; darkness still represented a time both sacred and dangerous for many. In certain places it remained custom to stay home, except for special occasions, and devote evenings to prayer and rest (Ekirch, 2005).

The first monumental technical development in nighttime lighting came at the turn of the nineteenth century with gaslight. It was with the adoption and proliferation of public gaslight that the modern notion of the city at night began to emerge, and nights started to become definitively brighter. Gaslight was first demonstrated publicly in 1807, in London, and over the next few decades it was quickly adopted across Europe and North America.³ Gaslight was seen as symbolic of modern progress; it reordered the chaos of nature into rational, scientific principles (Schivelbusch, 1988). *Turning night into day* and *lengthening the day* were popular expressions of the time (Schivelbusch, 1988), and with gaslight this became a technological possibility for the first time, not simply an ideal to strive for. People were shedding old habits and fears of the night, and increasingly staying out later for commercial and social reasons. Brox (2014) notes that by the mid-nineteenth century a new word came into use: *nightlife*.

Gaslight was followed by the invention of electric lighting in the latter half of the nineteenth century—the most profound technological development in lighting, and arguably one of the most important developments of modern infrastructure. Figuratively, electric

lighting became synonymous with—and symbolic of—modern progress. For a Russian poet visiting New York City in the 1920s, the bright electric lights were perceived as modernity's very medium (Isenstadt, 2014). Aided by various technical advances, for example, floodlights, electric lighting quickly became a 'sophisticated cultural apparatus' that could be used for advertising, commemorating history, expressing civic pride, highlighting monuments, etc. (Nye, 1990, p. 73). Via electrification, artificial nighttime lighting became, and remains, a prolific technological artifact capable of esthetic and ideological expression well beyond functional requirements.⁴

Any scarcity of urban nighttime illumination was quickly diminishing as electrification spread across North American and Europe during the twentieth century, developing alongside urbanization and the growth of transportation networks (Isenstadt, 2014). This proliferation of nighttime illumination has been continuous to the present day, save for two major disruptions: World War Two and the energy crisis of the 1970s. However, nighttime illumination efforts quickly resumed shortly after both of these events (Neumann, 2002b). Current estimates are that artificial nighttime lighting continues to increase globally by about 3–6% annually (Hölker et al., 2010). This has been, in many ways, the ultimate realization of values strived for since the seventeenth century. A *lengthening of the day* has effectively been achieved, creating unmistakably modern nights where the various facets of nightlife can occur, and where many daytime activities can continue well into the night. But this has come with unintended consequences. In his exploration of 'the world after dark', Dewdney (2004, p. 101) cleverly evaluates the two-sided nature of this achievement, stating,

The radical effect of the electric lightbulb cannot be overstated. More than any lighting technology that preceded it—candles, oil lamps, or gas lighting—the electric light revolutionized the night. Now the darkness, at least in cities, was in full retreat.

From Lengthening the Day to Losing the Night: The Emergence of 'Light Pollution'

It is worthwhile to quickly note that, as with most transformational technologies, nighttime lighting has not always been met with open arms. Hasenöhl (2014, p. 105) notes that while the introduction of new lighting technologies was in general positively received, this did not imply universal endorsement or 'a universal devaluation of the "dark night" as a whole'. The consequences of artificial nighttime lighting have been under debate since the nineteenth century, and some criticisms of artificial nighttime lighting can be found even earlier.⁵ The most outspoken critics have been astronomers, as reduced stellar visibility has been a long-noticed effect of urban lighting (Sperling, 1991). Still, in the larger narrative of lighting technologies these objections were the exception—nighttime lighting was mostly seen as necessary and desirable for modern urban life (Hasenöhl, 2014).

With electric light, the illumination of our urban nightscapes was effectively realized. But with this realization, a critical shift in perception was occurring underneath the spread of electricity. As new generations were born into a world of abundant electric light, it began losing its mysticism. Electric lighting, once dazzling and even otherworldly, began fading into banality as early as the 1920s (Isenstadt, 2014). By the 1930s, light was no longer considered a spectacle but sank into the background of everyday life (Nye, 1990). An abundance of light has become the expectation for urban nights in North America and Europe. As a consequence of this shift, lighting infrastructure went (and remains) largely unnoticed. It is

only when lighting fails (e.g. power outages) or during unique displays that we notice the technology.

Nighttime illumination, once scarce, is now possessed in abundance and unavoidably ubiquitous. As a result, though, an interrelated shift in perception and valuation emerged—a shift that is critical to present discourse. With this abundance and ubiquity, a renewed attention was given to what is hindered by light. Darkness became, as Hasenöhrle notes, a valorized and ‘sought-after luxury’ of our electrified nights (2014, p. 119). As a result, our taken-for-granted infrastructure of artificial nighttime lighting has been re-noticed, but in a new light. Concerns are increasingly articulated through a sense of loss—a loss of connection to starlight, or an aspect of nature, or the sublime, or a piece of our humanity—brought about by the loss of dark or ‘natural’ nights (e.g. Bogard, 2013).

The concept of light pollution coalesced in the early 1970s, amid a climate of political activism, rising environmental awareness, and an energy crisis. In discussing lighting conflicts in Germany—but providing generally applicable conclusions—Hasenöhrle (2014, p. 119) notes that ‘it was not before the oil crises and the growing environmental and heritage movements of the 1970s that lighting as a particularly visible form of energy consumption and as an object of cultural value regained public and political attention’. Lighting, at this point a ubiquitous everyday experience, was given new attention but in a very different framework: that it is polluting the night sky. Sperling (1991) gives a brief narrative of the term’s popularization, explaining that in the politically charged atmosphere of the 1960s and 1970s astronomers began advocating for the curbing of excess lighting detrimental to starlight visibility. Then during the 1973 energy crisis urban areas saw an increase in energy conservation efforts, resulting in decreases to public lighting (Neumann, 2002b). Astronomers used the anti-waste strategies of the time to fight excess artificial nighttime brightness, which is when, according to Sperling, ‘the struggle took on its current aspect’ (1991, p. 103). Thus, it was an opportune moment for astronomers to advocate for the mitigation of certain aspects of nighttime lighting. Around this time a paper was published in *Science* titled ‘Light Pollution: Outdoor lighting is a growing threat to astronomy’ (Riegel, 1973), which seemingly marks the academic acceptance and adoption of the concept.

Light Pollution in Contemporary Discourse

Since its introduction by astronomers the concept of light pollution has been gaining momentum and widespread acceptance. Contemporary understandings of light pollution focus on categorizing the negative consequences of artificial lighting across a range of disciplines. Thus, it can be defined in many different ways, creating some issues with ambiguity (Morgan-Taylor, 2014). However, efforts have been made to provide a universal definition and to codify negative effects, which go well beyond a sort of Luddism or a nostalgic pining for more darkness. The International Dark-Sky Association, arguably the leading authority on light pollution, defines light pollution simply as ‘any adverse effect of artificial light’ (IDA, 2014). A more nuanced articulation of the concept states, ‘the unintended consequences of poorly designed and injudiciously used artificial lighting are known as light pollution’ (Gallaway, 2010, p. 72).

What all definitions have in common—either explicitly or implicitly—is the goal of establishing a base upon which the negative effects of artificial nighttime illumination can be categorized. Toward this end, Gallaway’s definition opens us to the broader range of concerns

embodied by the contemporary usage of the term—light pollution is not meant to condemn nighttime lighting as a whole, but rather specific uses and outputs of artificial lighting. These negative or undesired aspects of nighttime lighting can be subdivided into four categories: *skyglow*, *glare*, *light trespass*, and *clutter*.⁶ Skyglow is light sent upward (directly or reflected) and scattered in the atmosphere, causing artificial ambient brightness and decreasing stellar visibility (Mizon, 2012). This is the orange haze often seen above cities, and the largest burden for astronomy. It has also arguably been the dominant focus of efforts to quantify light pollution, as some landmark studies rely on satellite imagery (e.g. Cinzano, Falchi, & Elvidge, 2001). The other three forms of light pollution are more commonly experienced hinderances in daily life: glare occurs when excessive brightness reduces visibility (e.g. a floodlight at eye level), light trespass is unwanted or unintended light (e.g. light shining into your bedroom window at night), and clutter is caused by over-illuminated clusters of light sources (e.g. signage and advertising) (IDA, 2014; Morgan-Taylor, 2014).

With this definition and sub-categorization, the use of light pollution as a framework for evaluating artificial nighttime lighting begins to come into focus. The undesired outputs of artificial nighttime lighting—be it any of the four broad types listed above—can then be considered in terms of effects. The consequences of light pollution are far reaching, and supporting research is often still at an early stage. However, the effects can likewise be subdivided into five broad categories: *energy usage*, *ecology*, *health*, *safety*, and *the night sky*. The past few decades have seen the first large-scale investigations of energy usage by artificial nighttime lighting, as well as its connection to economic costs and greenhouse gas emissions. The International Dark-Sky Association estimates that 22% of all energy in the USA is used for lighting, and of that around 8% is used for outdoor nighttime lighting (IDA, 2014). Another recent study concluded that this number is closer to 6% (Gallaway, Olsen, & Mitchell, 2010). Such studies often focus not just on the amount of energy used for lighting, but specifically the amount of *wasted* light. A consistent estimate is that approximately 30% of outdoor lighting in the United States is wasted (Gallaway et al., 2010; Henderson, 2010).⁷ This translates into roughly 73 million megawatt hours of ‘needlessly generated’ electricity, with an estimated annual cost of US\$6.9 billion. Elimating this wasted light, in terms of CO₂ reduction, is equivalent to removing 9.5 million cars from the road (Gallaway et al., 2010). Similar estimates of wasted light in the European Union have predicted that the direct costs amount to €5.2 billion, or 23.5 billion kg of CO₂ annually (Morgan-Taylor, 2014).

Research is also examining the effects on flora and fauna, especially birds, bats, turtles, and insects. While a few species benefit from increased brightness at night, many are negatively affected. Perhaps most notable are the effects of artificial light on migrating birds and newly hatched turtles attempting to reach the ocean (Gallaway, 2010; Pottharst & Könecke, 2013). The effects of artificial lighting on human health first emerged in the late 1960s, but have gained more attention by medical researchers in the last few decades. Pottharst and Könecke (2013) summarize ongoing research correlating nighttime lighting—and more specifically disruptions to our circadian rhythm—to insomnia, depression, obesity, loss of night-vision, and the suppression of melatonin (which is potentially linked to an increased risk of breast cancer). While the precise connection between human well-being and exposure to artificial nighttime lighting requires further research, the World Health Organization has nevertheless stated that exposure to certain lights at night is likely a carcinogen (Morgan-Taylor, 2014).

The relationship between safety and lighting at night is complex at best, and often controversial. Historical surveys into the origins of public nighttime lighting (e.g. Ekirch, 2005) describe the storied relationship between the value of safety and lighting efforts. Lighting served the practical function of making nighttime travel safer, but also the symbolic function of protection from the evils of the night (spirits, demons, etc.). In contemporary discourse, the exact relationship between safety and security and nighttime lighting remains contentious, with various studies proving or disproving a correlation (Pottharst & Könecke, 2013). It is outside the scope of this paper to comment on these studies in detail, but it is important to note that advocates for mitigating light pollution often cite the possibility that less (or more wisely designed) lighting may improve safety and reduce crime (e.g. Bogard, 2013; Henderson, 2010).

Concerns have also remained regarding the inverse of proliferating nighttime lighting, namely the rapidly declining access to a natural night sky in the developed world. In recent decades attempts to quantify skyglow and its global presence have emerged, however, data is still somewhat sparse. The first attempt to map this phenomenon on a global scale was published by Cinzano et al. (2001). A more recent study by Gallaway et al. (2010) built on their findings and concluded that the amount of people living in areas with a 'polluted night sky' is extremely high: around 99% in both North America and the European Union.⁸ Furthermore, on both continents approximately 70% of the population lives in areas where brightness at night is at least three times natural levels. From a dark rural area, our unaided eyes can normally see up to 3,000 stars; people with strong eyesight can even see close to 7,000 stars. However, in many urban areas today this number is reduced to around 50, or perhaps even less (Mizon, 2012). Researchers caution that if the current pace of increasing brightness continues, the 'pristine night sky' could become 'extinct' in the continental United States by 2025 (Fischer, 2011).

Questions for the Moral Space Created by Light Pollution

We began with a problem (*we have too much light at night*) and a related question (*how much artificial light at night is appropriate?*). We now have the origins, context, and detailed definition in hand for the concept of light pollution. With this, we can return to the question of framing outlined in Section 2, and scrutinize the ethical significance of increasingly relying on light pollution for policy decision-making; we can assess the answer light pollution provides for our question. Increased regulation and alternative design approaches will be necessary to address the myriad of undesired effects uncovered in contemporary research. And, light pollution offers a framing to orient responses. Furthermore, in its broad understanding of causes and effects, light pollution accommodates a variety of interpretations, allowing for a multiplicity of regulatory and technical solutions. Dark sky ordinances and new laws already exist, which often include detailed technical specifications.⁹ However, it is pertinent to reflect on the framework in which these decisions were made, and to consider how light pollution will shape future initiatives.

The below discussion is organized under two broad questions, with the aim of elucidating the moral limitations and practical ambiguities existing within the concept of light pollution, when considered as a framework for moral and political decision-making. These two sections should not be seen as mutually exclusive, but as actively informing one another.

What are the Normative Limitations of the Concept of Light Pollution?

A first step is to consider the limitations for application, for which a consideration of language will be helpful. As the above discussion in Section 3 makes clear, light pollution is not simply a description of certain environmental impacts, but also an evaluation of the effects of nighttime lighting technologies and infrastructure. Light pollution is both a descriptive statement and a value judgment with normative implications—it categorizes certain uses and types of lighting as *bad* or *wrong*. Historically lighting often functioned as a form of safety and protection at night, but there has been a reversal. Now humans, animals, and the night sky require protection from artificial light. Importantly, articulating this shift in perspective via the notion of light as a *pollutant* adds a moral level to an otherwise technical discussion of illumination. But, in considering the creation of a moral space for deliberation, we should reflect on the implications of this label. Garrard (2004), in assessing Rachel Carson's iconic *Silent Spring*, notes that one of the book's lasting achievements was expanding what was previously seen as a scientific issue (the usage of pesticides) into a social problem. By this, Garrard is referring to the categorization of pesticides as pollution. This is because 'pollution' does not name an actual thing, but rather provides an implicit normative claim that 'too much of something is present in the environment, usually in the wrong place' (2004, p. 6). Carson helped to reframe perspectives, allowing the usage of pesticides to be contested morally and politically. The same can be said of the concept of light pollution, generally considered: it breaks with the historical meanings and values associated with nighttime lighting, reframing discussions as a debate over how we ought to preserve and protect the night sky, as well as protect ourselves and ecosystems, from excess artificial light.

We can see the emergence of the concept of light pollution as—at least in part—a reactionary shift in perception to the widespread proliferation of electric illumination at night. A recent *New York Times* article quoted a behavioral ecologist as stating that we need to 'start thinking of a photon as a potential pollutant' (St. Fleur, 2016). To accept this re-framing is to begin seeing artificial nighttime lighting as spreading polluting photons into the atmosphere, the environment, and ourselves. Answers will likely take the form of either preservation or mitigation strategies—certainly not a bad approach, but it does draw attention to the importance of light pollution as a framework through which solutions can emerge. Regulations and strategies based on light pollution will necessarily focus on reducing the negative or adverse effects of nighttime lighting; on protecting those things or resources affected, and/or cutting out that 30% of lighting considered to be 'wasted' (Gallaway et al., 2010). As a regulatory tool, this can be quite useful, and follows a similar strategy as attempts to regulate other pollutants.

Attaching the language and connotations of *pollution* to nighttime lighting is effective, but may also set boundaries on possible solutions. This is a very specific answer to the question of how much light is appropriate, which comes with limitations. As a moral concept, light pollution can tell us what *bad* lighting is, but says relatively little about what *good* lighting is. Because of the focus on the (adverse) causes and effects of artificial nighttime lighting, the concept is limited in its capacity to inform choices within the realm good lighting, especially in cities where there are other values at play. Light pollution says very little about artificial nighttime illumination deemed to be within the acceptable limits of polluting, or the many values and needs strived for therein (for example, esthetics and nightlife). Thus, there are limits to the capacity of light pollution to inform moral evaluations, as it frames decisions as questions about acceptable levels of polluting.

What are the Practical Ambiguities of the Concept of Light Pollution?

With the limitations known, we can next consider how to strengthen practical applications. Operating effectively in such a capacity necessarily means establishing the boundaries or thresholds for lighting considered to be ‘polluting’. If we focus solely on mitigating the negative or adverse effects of artificial nighttime illumination, we must then define what qualifies as *negative* or *adverse*, as well as what the acceptable levels of these effects are. And these levels—which will effectively delineate between good and bad lighting—should not be arbitrary or ambiguous.

This comes with a rather unique set of challenges, because what is polluting for one person can be acceptable or even desirable lighting for another. There are uses of light that are necessary at night, especially in cities; no ‘dark sky advocate’ would deny that. And there are obvious instances of excessive brightness and poorly designed lighting, which most reasonable people would agree is unnecessary and wasteful. But, there will also be instances that fall somewhere in an intermediary, gray area. These could be instances where the lighting does not obviously fall into one of the sub-categories of light pollution, or does not relate directly to one of the identified effects of light pollution, or is contested as a good by some stakeholders and a nuisance or excess by others. Or, it could be a new technological innovation that reduces energy consumption but will potentially increase skyglow—an emerging issue connected to LEDs (Morgan-Taylor, 2014). In these instances, we will see the weighing of benefits versus negative effects by regulatory decision-makers. It is unclear how the current conception of light pollution can be used to resolve such conflicts, without drawing upon a larger moral framework—for example, a formulation of the precautionary principle, a definition of sustainable development, or perhaps an explicit focus on minimizing energy usage—that helps to elucidate exactly what an acceptable level of pollution is. And, different approaches may rely on rights-based or consequentialist moral frameworks. These may, in turn, offer different boundary conditions for what qualifies as acceptable levels of light pollution. For example, in 2007, a group of astronomers published the Starlight Declaration, asserting that access to the night sky should be an ‘inalienable right of humankind’ (Starlight Initiative, 2007, p. 3). Adopting such a rights-based approach would likely yield different conclusions than, say, a cost-benefit analysis. We would then need to ask if light pollution is, or should be, beholden to one broader moral framework, or how different manifestations can be reconciled. If we recall the discussion of defining problems within policy as a means to guide action (Stone, 2002), the concept of light pollution therefore requires further parameters beyond the causes and effects listed above.

Current calls for mitigation are often rested on an appeal to needs. For example, the International Dark-Sky Association cites needs-based principles of lighting as a way to minimize the negative effects of light pollution (IDA, 2014). It seems to follow that ‘unneeded’ nighttime illumination equates to light pollution, and therefore, contributes to the pre-defined negative effects. For, at the least, lighting deemed unnecessary wastes energy. This requires a clear justification for what is ‘needed’ nighttime illumination, which is both a quantitative and qualitative question. However, the moral terrain of such claims has been left largely unexplored. A needs-based approach requires that we can confidently point to criteria for needed lighting. Yet, as historic surveys on nighttime lighting makes clear, the blurring of symbolic and actual needs of nighttime lighting are complex at best, and needs are co-constituted by societal perceptions and values (Nye, 1990; Schivelbusch, 1988). If policies aimed at light pollution mitigation adopt a needs-based approach, adequate

reasoning should be given for why a different approach—say one geared toward preferences and desires—is insufficient.

Kyba et al. (2014) mention the tricky issue of ‘shifting baseline syndrome’. As nights get brighter, people have a new conception of what ‘normal’ levels of light are, and base their evaluations of acceptable levels of brightness on this. A focus on needs could help to overcome shifting baselines. But, such an approach risks omitting the preferences of local stakeholders, and as such may create technocratic and paternalistic policies. This may contribute to downstream value-level conflicts when regulations are enacted. For example, safety is a central facet of nighttime lighting and an important value intertwined with urban nightscapes. While the correlation between increased lighting and increased safety is contentious, research suggests that lighting influences feelings and perceptions of safety (King, 2010), and that feelings of fear increase at night (Li et al., 2015). Such findings represent a challenge for needs-based nighttime lighting efforts. Attention to the preferences of local stakeholders becomes critical to the creation of regulations that will be supported and successful. The frame creation model discussed above (Dorst, 2015) is but one approach that incorporates the values and desires of stakeholders; a variety of other participatory or value-focused design strategies could also be effectively utilized to address conflicts of this nature.

In establishing an acceptable level of polluting, some clarification of qualitative values will strengthen future decisions. Consider the research by Gallaway (2014), who explores the instrumental value of the night sky for promoting the broadly held values of happiness and sustainability. He concludes by stating, ‘We suggest that estimating the night’s value is not nearly as important as simply recognizing that it does have enormous value and then trying to preserve this value and put it to good use’ (p. 280). Gallaway’s discussion of key night sky traits includes its ability to connect us to the natural world, its ability to engender a sense of wonder, and its beauty. Such an articulation of the value of reducing light pollution falls outside traditional economic calculations, as discussed elsewhere by Gallaway (2010). It also further calls into question a needs-based approach. As a frame, light pollution will set the boundaries on what sort of answers are possible, which requires a careful consideration of how ‘needs’ are defined, and what needs ought to be encapsulated by future policies.

Clarifications to the ambiguities discussed above will likely change alongside differences in geographies, cultures, and belief systems. The recent edited volume *Cities of Light* (Isenstadt et al., 2014) provides a first overview of historic developments in nighttime illumination with respect to individual cities, a format that could be expanded to contemporary environmental debates. But regardless, if light pollution will be the frame through which regulations are established, anticipating value-level conflicts and ambiguities is important. We must clarify—or at the least debate—the normative foundations of light pollution before the framework becomes normalized and fades into the background of presuppositions informing nighttime lighting strategies.

Conclusion

This paper has critically engaged with the concept of light pollution and identified areas that require further clarification. The limitation of light pollution as a criterion for the moral evaluation of artificial nighttime lighting was discussed, concluding that it can best function in the limited capacity of mitigation or preservation efforts. This led to practical concerns, specifically the ambiguity of thresholds for acceptable levels of light pollution, and the

mechanisms that could be used to establish said thresholds. The intention was to highlight conceptual and practical issues that, if addressed, can help to strengthen future regulatory efforts in urban nighttime lighting.

The 350 year project of illuminating our nights has produced a challenging situation. The desire for more and better lighting at night has left us with an overabundance of artificial illumination, and has produced a novel problem. The realization of *lengthening the day* is increasingly perceived as a *loss of the night*, and a new frame has emerged to give shape to these concerns. The story of light pollution goes back much further than the 1970s, in juxtaposition but nevertheless linked to the technical and social history of modern nighttime illumination. Importantly, the concept of light pollution re-frames certain aspects and uses of nighttime lighting technologies. If we return once more to the driving question (*how much artificial light at night is appropriate?*), we can appreciate that the concept of light pollution provides a new starting point, and not an end point, for discussions about the future of nighttime lighting.¹⁰

Notes

1. These effects are described in more detail in Section 3.3.
2. For a summary of these societal changes, see Ekirch's *At Day's Close* (2005, p. 72).
3. For example, by 1823 London had nearly 40,000 gas lamps covering over 200 miles of streets (Ekirch, 2005).
4. Neumann's *Architecture of the Night* (2002a) is arguably the most important recent study of nighttime illumination in architectural history and theory, linking the history of nighttime lighting with the history of modern architecture. Neumann mainly focuses on the esthetic and expressive qualities of 'illuminated buildings' throughout the nineteenth and twentieth centuries, providing the first comprehensive catalogue of relevant architectural projects.
5. Criticisms can be found as early as 1662, when a London pastor stated 'We ought not to turn day into night, nor night into day ... without some very special and urgent occasion' (Ekirch, 2005, p. 74). This was due to the disruption of the perceived natural (Christian) order that such lighting may cause. However, most criticisms are found in the nineteenth century onward, and specifically around times of transition between technologies. Early objections were often esthetic, however moral objections can also be found (Hasenöhr, 2014). There are documented criticisms of artificial nighttime lighting in astronomy-related literature as early as 1866 (Sperling, 1991). Already in the 1880s, Alexander Pelham Tottler—generally regarded as the originator of the scientific study of lighting—identified issues with street lighting that predict modern debates. For example, he argued that too much light is wasted, and that glare causes safety concerns (Bowers, 1998). Naturalists and artists expressed ambiguity (at best) towards artificial light as early as the 1920s (Nye, 1990), and by this time there were already some calls for lighting engineers to reduce urban brightness (Isenstadt, 2014).
6. These four categories of light pollution are used (although with slightly different terms) by the International Dark-Sky Association, and cited elsewhere as well (e.g. Morgan-Taylor, 2014). As such, I am accepting these as the standard causes of light pollution.
7. By wasted, we can assume this percentage of lighting is deemed to fall within one (or more) of the categories listed above (skyglow, glare, light trespass, or clutter).
8. Gallaway et al. (2010) utilize the threshold criteria established by Cinzano et al. (2001) for considering an area 'polluted' by light. These criteria 'consider the night sky polluted when the artificial brightness of the sky is greater than 10% of the natural sky brightness above 45° of elevation' (Gallaway et al., 2010, p. 660).
9. Morgan-Taylor (2014) provides a brief analysis of current regulatory efforts in Europe. France is cited as having perhaps the strongest law to date, which requires non-residential buildings to switch off exterior lights and window displays between 1am and 7am. Other examples cited

include regions of Italy that have taken a technical approach, prohibited lights above a specific brightness to project above the horizontal. Additionally, an online appendix to the article by Kyba et al. (2014) lists all known regulations and ordinances that are currently in place, as well as their motivations and targets.

10. I would like to thank the anonymous reviewer for this insight.

Acknowledgments

I am grateful to the 4TU.Centre for Ethics and Technology (ethicsandtechnology.eu), through which my position is made possible. Earlier drafts of this paper were presented at the Annual Meeting of the Consortium for Socially Relevant Philosophy of/in Science and Engineering (SRPoISE), held in Detroit in March 2015, and at the Biennial Conference of the Society for Philosophy and Technology (SPT), held in Shenyang (China) in July 2015. In addition to thanking the audiences at these conferences, I wish to thank Pieter Vermaas, Behnam Taebi, and the anonymous reviewer for their useful comments.

Disclosure statement

No potential conflict of interest was reported by the author.

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