

Dark Sky Initiatives in Stanley, Idaho An Exploration into a 'Dark Sky Friendly' LED Streetlight Retrofit & Community Experiences with Dark Skies and Dark Sky Advocacy

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Dark Sky Initiatives in Stanley, Idaho:
An Exploration into a 'Dark Sky Friendly' LED Streetlight Retrofit
& Community Experiences with Dark Skies and Dark Sky Advocacy

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September 2020



Master's Degrees by Examination and Dissertation

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Abstract

This dissertation discusses a case study of a community involved in dark sky initiatives: Stanley, Idaho, U.S.A. Its aims are twofold: to obtain an in-depth understanding of the town's recent 'dark sky friendly' LED streetlight retrofit and to explore community members' thoughts and experiences with dark skies and dark sky advocacy. It examines technical attributes of the lights chosen for the retrofit, the process necessary for this project to come to completion, and community members' responses to the change in lighting and to dark skies more generally. In particular, it seeks to gain insight into the experiences of key actors involved with dark sky initiatives in this community and to explore more deeply their thoughts and feelings in relation to dark sky advocacy and the night sky.

This research uses a mixed method approach, utilizing semi-structured interviews and an online questionnaire to gather community members' thoughts on these issues. Stanley is located within the Central Idaho Dark Sky Reserve and has a long history of interest in dark sky preservation. Providing an example of 'best practice' dark sky lighting was among the reasons cited for implementing the city-wide retrofit of 2200 K fully-shielded LED streetlights. Based on interview and questionnaire findings, it appeared that overall, the retrofit was well-received by most Stanley-area residents.

The success of this endeavor, as well as that of implementing dark sky friendly lighting more broadly across the region, was a result of long-term, ongoing efforts of dark sky advocates to effectively communicate reasons for using such lighting, listen to the thoughts of others in the community, and work together to implement workable solutions. Many research participants mentioned the importance of starry night skies in regard to their quality of life, and nearly all believed that it was important to maintain the area's dark night skies.

Chapter 1: Introduction

This dissertation reports on a case study which examines a 'dark sky friendly' LED streetlight retrofit and the thoughts of community members about lighting and dark skies in the community of Stanley, a small rural town located in the Central Idaho Dark Sky Reserve in the U.S.A. The purpose of this research is to gain a deeper understanding of a community which has engaged in initiatives intended to preserve dark skies and provide effective lighting which minimizes light pollution. It will examine what kind of lighting was used in the retrofit, why it was chosen, and how community members felt about both the new streetlights and dark skies. In addition, it will delve into the experiences of those involved in advocating for dark sky friendly lighting in and around Stanley, aiming to gain insight into their reflections on dark sky advocacy and the starry night sky itself. These research objectives will be based in a review of primary and secondary sources, while my findings will result from semi-structured interviews and an online questionnaire.

'Dark sky friendly' lighting is lighting which illuminates areas where lighting is needed for human activity at night, while doing so in a manner which minimizes light pollution - 'excessive and inappropriate artificial light at night.'¹ Light pollution has numerous consequences and is steadily increasing, both in terms of the area of the Earth which is affected and in terms of the magnitude of the pollution. This can be seen, for example, in maps showing the relative intensity of artificial sky brightness at night in North America from various points in time (see fig. 1). Light pollution brightens the sky, making the Milky Way and other celestial objects invisible. As Fabio Falchi *et al* have found, close to 80% of people in North America can no longer see the Milky Way due to light pollution, and the same is true for 60% of the European population.² This is not only problematic for professional and amateur astronomers; it also prevents the ordinary person from being able to see much of what is outside earth's atmosphere and from

¹ International Dark-Sky Association, *Fighting Light Pollution* (Mechanicsburg, PA: Stackpole Books, 2012), p. vii.

² Fabio Falchi, Pierantonio Cinzano, Dan Duriscoe, Christopher C. M. Kyba, Christopher D. Elvidge, Kimberly Baugh, Boris A. Portnov, Nataliya A. Rybnikova and Riccardo Furgoni, 'The new world atlas of artificial night sky brightness,' *Science Advances*, 2 (6), American Association for the Advancement of Science, (2016). p. 1.

having a personal, firsthand experience of and connection to the larger universe. In addition, light fixtures which emit light sideways and upwards create glare, a source of visual discomfort for people driving or walking at night. Furthermore, light pollution affects the physiology and behavior of many species of wildlife and can have adverse consequences for these creatures.

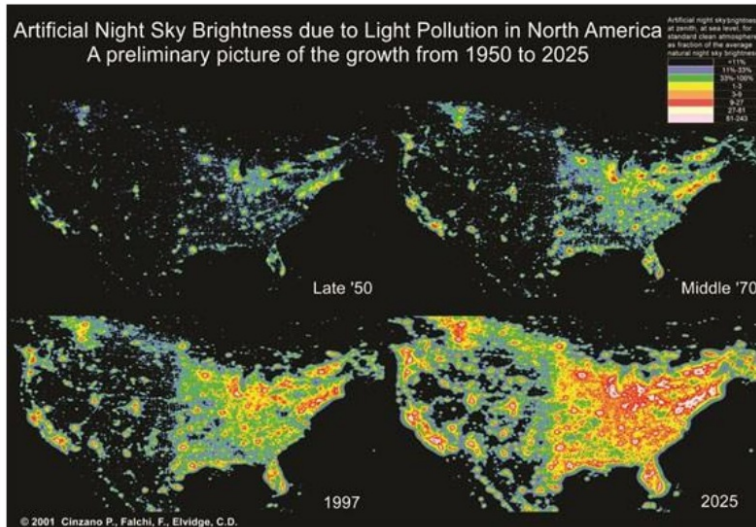


Figure 1: Artificial Night Sky Brightness in North America, 'Simulation of light pollution growth in the United States: 1950s, 1970s, 1990s, and projected to 2025.' Credit: P. Cinzano, F. Falchi, C. D. Elvidge. Copyright 2001 ISTIL, Thiene. Reproduced from ISTIL Report 2001. Rapporto ISTIL 2001- Stato del cielo notturno e inquinamento luminoso in Italia; ISBN 88-88517-00-6 <<https://www.nps.gov/subjects/nightskies/growth.htm>> [accessed 22 February 2020].

The use of light emitting diodes (LEDs) in exterior lighting applications has greatly hastened the spread and increased the extent of these issues. In the past several years, many communities have begun replacing their existing exterior lights with LED fixtures. LEDs are more energy efficient than older kinds of outdoor lighting, and the cost of LEDs has decreased substantially in recent years, thus making the switch to LED streetlights an increasingly affordable option for

municipalities. Though the intention behind such retrofits is typically to save money, reduce energy consumption, and thus be more environmentally friendly, the reality has proven to be more complex.

Many of the LEDs commonly used produce whiter light and emit much more light in the blue part of the spectrum than High Pressure Sodium (HPS) lighting - an exterior lighting technology widely used before the advent of LEDs. Exposure to such blue-rich white light at night is associated with concerns ranging from negative consequences for the health of wildlife and humans, to greatly increased skyglow and light pollution. For example, in a New Zealand study, S.M. Pawson and M.K.F. Bader found that, on average, 48% more insects were attracted to light traps with white LEDs than HPS lamps.³ White LEDs also are highly disruptive to sea turtles. For instance, Marga Rivas *et al* found white and blue light to be more disorienting for Leatherback sea turtle hatchlings than other colors of light.⁴ Concerning consequences of exposure to blue-rich light at night for humans include disruption of circadian rhythm and melatonin production, as well as potential links to other health issues.⁵ In addition, blue-rich LED light sources, when used in a nighttime environment, appear more glaring in comparison to those lacking significant amounts of blue light.⁶ Thus when utilized in streetlights and vehicle headlights, for instance, such lights can result in increased visual discomfort for drivers and pedestrians whose eyes intercept the beam of light.⁷ Blue-rich light also creates much more skyglow - 'the brightening of the night sky over inhabited areas,' due to the ease with which blue light scatters in the

³ S.M. Pawson and M.K.F. Bader, 'LED lighting increases the ecological impact of light pollution irrespective of color temperature,' *Ecological Applications*, 24 (7), (2014), p. 1561.

⁴ Marga L. Rivas, Pilar Santidrián Tomillo, Javier Diéguez Uribeondo, and Adolfo Marco, 'Leatherback Hatchling sea-finding in response to artificial lighting: Interaction between wavelength and moonlight,' *Journal of Experimental Marine Biology and Ecology*, 463 (2015), p. 143.

⁵ Royal Society Te Apārangi, *Blue Light Aotearoa: Impacts of Artificial Blue Light on Health and the Environment* (Wellington, New Zealand: Royal Society Te Apārangi, 2018), pp. 11-14.

⁶ International Dark-Sky Association, *Fighting Light Pollution*, p. 94.

⁷ Michael Sivak, Brandon Schoettle, Takako Minoda, and Michael J. Flannagan, 'Short-Wavelength Content of LED Headlamps and Discomfort Glare,' *LEUKOS: The Journal of the Illuminating Engineering Society*, 2 (2005) 145-154.

atmosphere.⁸ As Falchi *et al* observe, 'unless blue-light emission is restricted, a transition toward this technology [LEDs] can be expected to more than double the night sky brightness as perceived by our dark-adapted eyes.'⁹ Thus, the widespread implementation of blue-rich LEDs is having a marked impact on the nighttime environment.

Though such blue-rich LEDs are currently more commonplace in new lighting installations, there are LED options available which emit far less blue light and thus minimize such impacts. In some locales, people have chosen to implement exterior LED lighting that produces warmer light (light toward the orange and yellow part of the spectrum) and are designed to minimize glare and uplight (light going up into the sky).¹⁰ Such communities are often concerned about the health and ecological effects associated with blue-rich LED lighting, the aesthetics of the light, and/or they are interested in preserving or recovering their dark skies. The number of such communities is increasing in number and many are featured on websites of the non-profit International Dark Sky Association (IDA) and the Royal Astronomical Society of Canada (RASC).¹¹

However, in general, awareness of light pollution and unintended consequences of blue-rich LED lighting is quite minimal, not only in the general public, but also among community decision makers selecting new streetlights. Understandably, most such individuals are not experts in physics, ecology, or human health. Their chief aim in the context of public lighting is to provide their community with light at night for lower cost, which is exactly what LEDs deliver. However, this lack of understanding of the undesirable effects of the common blue-rich white LEDs and

⁸ International Dark-Sky Association, *Fighting Light Pollution* (Mechanicsburg, PA: Stackpole Books, 2012), p. vii; Christian B. Luginbuhl, Paul A. Boley, and Donald R. Davis, 'The Impact of Light Source Spectral Power Distribution on Sky Glow,' *Journal of Quantitative Spectroscopy and Radiative Transfer*, 139 (2014), p. 21.

⁹ Fabio Falchi, *et al*, 'The new world atlas of artificial night sky brightness,' p. 7.

¹⁰ For example, see 'Fulda: Dark Sky City: Application for Provisional Designation of the City of Fulda as an International Dark Sky Community,' (Approved by the International Dark Sky Association in 2019); Mont-Mégantique International Dark-Sky Reserve, 'Annual Report,' (2019).

¹¹ International Dark-Sky Association, *International Dark Sky Places*, <<https://www.darksky.org/our-work/conservation/idsps/>>, [accessed 12 July, 2020]; Royal Astronomical Society of Canada, *Dark-Sky Programs*, <<https://www.rasc.ca/dark-sky-site-designations>> [accessed 12 July, 2020.]

lack of knowledge of the existence of cost-effective alternatives means that much of the time, a switch to LED streetlight installations worsen a community's level of light pollution.

Another reason why adoption of LEDs can increase light pollution lies in their efficiency. Christopher Kyba *et al* have found that light pollution levels have been increasing by about 2% a year worldwide between 2012 and 2016 (a timeframe within which LEDs had begun to be more widely used).¹² The savings from LEDs' efficiency is often not fully utilized, with some of the savings often being allocated towards additional lighting. Thus, paradoxically, the availability of relatively low cost and efficient LEDs may result in an increase in outdoor lighting, particularly in parts of the world which formerly emitted little light pollution. Though LEDs have the potential to revolutionize humans' ability to decrease light pollution (dimmers, motion sensors, and timers can be put to better use than with older lighting technology, directionality of light can be more precisely aimed, and spectral emissions can be altered so as to emit less light in undesirable parts of the spectrum) without intentional use of such features, widespread use of LEDs appears to be contributing to increasing levels of light pollution worldwide.

As LED lighting becomes more ubiquitous, increasing research is being conducted to learn about its effects - in disciplines as diverse as wildlife biology, human health, and astronomy. The breadth of such research can be seen, for instance, in abstracts found in the ALAN 2018 conference handbook.¹³ Though the study of effects of artificial light at night (ALAN) is still a developing field, sufficient research has been done to show that light pollution and widespread use of blue-rich white LEDs in particular, have numerous problematic consequences for the health and well-being of humans and ecological systems alike. However, to date, comparatively little academic work has delved into the actions and motivations of dark sky advocates and other key decision makers involved with

¹² Christopher C. Kyba, Theres Kuester, Alejandro Sánchez de Miguel, Kimberly Baugh, Andreas Jechow, Franz Höller, Jonathan Bennie, Christopher D. Elvidge, Kevin J. Gatson, and Luis Guanter, 'Artificially Lit Surface of Earth at Night Increasing in Radiance and Extent,' *Science Advances*, 3 (11), (2017) e170158.

¹³ ALAN, *ALAN 2018: 5th International Conference on Artificial Light at Night: November 11-14 Snowbird, Utah*. (2018).

dark sky initiatives. Similarly, there is a dearth of research focused upon understanding the nuances of the implementation of 'dark sky friendly' LED streetlight retrofits or exploring community responses to such retrofits. As Dietrich Henckel and Timothy Moss observe, 'research on the societal dimensions of lighting is still in its infancy'; they assert, 'the humanities and social sciences can provide valuable new insight and guidance for a more enlightened treatment of artificial light at night.'¹⁴ Thus, this dissertation, which examines both the implementation of 'dark sky friendly' lighting in a small town as well as the experiences of community members with dark sky initiatives, will bring new information and fresh perspectives to the emerging transdisciplinary research area of dark sky studies. Josiane Meier *et al* note, 'Artificial lighting is multifaceted in its qualities, utilization and interpretation. . . . When discussing light and regulating for light pollution, it is therefore indispensable not only to consider its ecological impacts, but also to reflect the historical, cultural and social dimensions of urban lighting.'¹⁵ This dissertation will touch upon such factors as it explores Stanley residents' perspectives on dark skies and the community's new streetlights.

¹⁴ Dietrich Henckel and Timothy Moss, 'Towards a Brighter Future? Conclusions for Lighting Research and Policy,' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), p. 303.

¹⁵ Josiane Meier, Merle Pottharst, Katharina Krause, and Ute Hasenöhr, 'The New Visibility of Lighting: An Introduction,' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), pp. 2-3.

Chapter 2: Literature Review

Though light pollution has many ecological, physiological, and societal effects, it is the astronomical community which has historically been most acutely aware of this issue.¹⁶ Throughout the 20th and 21st centuries, astronomical observatories have been increasingly affected by light pollution, resulting in urban observatories gradually losing their ability to conduct research and the trend to locate new observatories in ever more remote locales.¹⁷ Though activism to address impacts of light pollution began to gain some traction in the 1970's, and the non-profit International Dark-Sky Association (IDA) was created in 1988, it is only relatively recently that research into Artificial Light at Night (ALAN) and 'Dark Sky Studies' began to be seen as distinct subject areas of research.¹⁸ The first ALAN conference was in 2013, with a total of six international conferences having occurred thus far.¹⁹ Much of the research presented at these conferences has been focused on the sciences, though some research from other disciplines has been present.²⁰ Additionally, there have been four Light Pollution: Theory, Modeling and Measurement (LPTMM) conferences, with the first occurring in 2013.²¹ These conferences have a more narrow focus and are meant to help advance research

¹⁶ For example, see Kurt W. Rigel, 'Light Pollution: Outdoor Lighting Is a Growing Threat to Astronomy,' *Science*, 179(4080), American Association for the Advancement of Science, (1973), 1285-1291; Norman Sperling, 'The Disappearance of Darkness,' in *Light Pollution, Radio Interference, and Space Debris*, ed. by D.L. Crawford, ASP Conference Series, Vol. 17, IAU Colloquium 112, (1991), pp. 101-108.

¹⁷ For example, see International Astronomical Union Office for Astronomy Outreach, *Light Pollution Brochure*, (2018); Sperling, 'The Disappearance of Darkness.'

¹⁸ Sperling, 'The Disappearance of Darkness'; International Dark-Sky Association, *Fighting Light Pollution* (Mechanicsburg, PA: Stackpole Books, 2012), p. 163.

¹⁹ Artificial Light at Night, *ALAN-Archives*, <<http://www.artificiallightatnight.org/>> [accessed 24 August 2020].

²⁰ See Conference Abstract Books listed at Artificial Light at Night, *ALAN-Archives*, <<http://www.artificiallightatnight.org/>> [accessed 24 August 2020].

²¹ Light Pollution: Theory, Modeling and Measurement, *About LPTMM*, <<http://www.lptmm.org/>> [accessed 28 August 2020].

involving the measurement and modeling of light pollution, as well as the impact such pollution has on observational astronomy.²²

Another recent initiative focused on increasing academic attention given to dark sky issues is the Consortium for Dark Sky Studies (CDSS), which was founded in 2017 at the University of Utah in the U.S.A. as an academic center with the goal of 'facilitating research that is both trans-disciplinary and multi-institutional'.²³ The aim of such collaboration is to better enable research on dark sky issues from a wide variety of perspectives. In 2019, the University of Utah created a minor in 'Dark Sky Studies,' the first such academic program in the world.²⁴ That same year, the first issue of another of the University's initiatives, the Journal for Dark Sky Studies (JDSS) was published. This journal seeks to provide a forum for academic research into dark skies, to better facilitate 'holistic, integrative work,' and to address dark sky issues through 'various disciplinary lenses'.²⁵ Thus, though research into dark skies is still in its early stages, interest in this area is steadily increasing, as are various collaborative initiatives.

In recent years, the issue of LEDs and the spectra of light they emit has become a subject of importance and much discussion in the dark sky advocacy and research communities. 'Correlated color temperature' (CCT) is a term used to indicate 'the perceived color of a broad-spectrum light source' in terms of Kelvin (K).²⁶ The higher the CCT, the whiter the light in general and the greater the amount of light emitted in higher frequency parts of the spectrum, such as blue (very high CCT light often appears bluish). The lower the CCT, the more yellow or amber the color of the light tends to be and the lower the amount of high frequency light

²² Light Pollution: Theory, Modeling and Measurement, *About LPTMM*, <<http://www.lptmm.org/>> [accessed 28 August 2020].

²³ The Consortium for Dark Sky Studies, <<http://darksystudies.org/>> [accessed 28 August 2020].

²⁴ University of Utah, *U Develops First Dark Sky Studies Minor in the U.S.*, <<https://unews.utah.edu/u-develops-first-dark-sky-studies-minor-in-the-u-s/>> [accessed 2 August 2020].

²⁵ The Journal for Dark Sky Studies, Issue 0, the University of Utah, August 2019.

²⁶ Royal Society Te Apārangi, *Blue Light Aotearoa: Impacts of Artificial Blue Light on Health and the Environment* (Wellington, New Zealand: Royal Society Te Apārangi, 2018), p. 06.

emitted (see figs. 2 and 3). In the context of astronomy, hotter stars produce more light in higher frequencies and cooler stars produce more of their light in lower frequencies, hence the use of 'temperature' in the terminology. In the context of lighting technology such as LEDs, having a high or low CCT has nothing to do with the physical temperature of the light source, yet 'temperature' is still often used to indicate the color of the light emitted. However in the context of lighting (as opposed to astronomy), lower CCT light (such as 2700 K) is termed 'warmer' and higher CCT light (such as 6000 K) is referred to as 'cooler,' even though the associated 'temperature' would imply the opposite (see fig. 3).



Figure 2: Dropality, 'Matching Lights' Color Temperature to Your Home'
<<https://medium.com/@Dropality/matching-lights-color-temperature-to-your-home-8ee80cc79474>> [accessed 12 September 2020].



Figure 3: Rob Cohen, 'Does the Color Temperature of the White Light I Use to Illuminate My Graphics Really Matter?' Omtima Graphics Blog, posted 7 April 2017,
<<https://optimagraphicsblog.wordpress.com/2017/04/07/warm-light-cool-light-bright-light-right-light/>> [accessed 12 September 2020].

More specifics about the relative amounts of different frequencies emitted by a given light source can be found by examining its spectral power distribution (SPD). The smaller the number (wavelength in nanometers) on the bottom of a SPD graph, the higher the frequency. The larger the number, the lower the

frequency (blue light is higher frequency - red light is lower frequency). The graph below illustrates typical SPD for 3500 K and 5000 K LEDs, as well as for the older technologies of HPS and metal halide (see fig 4). The HPS spectra peaks in the middle of the graph: its light contains much yellow and orange but very little blue. In contrast, the 5000 K LED spectra peaks on the left side of the graph: its light consists in large part of blue light. The 3500 K LED has a shorter peak in the blue, meaning it emits less blue light than the 5000 K LED, though the amount of blue content is still significant.

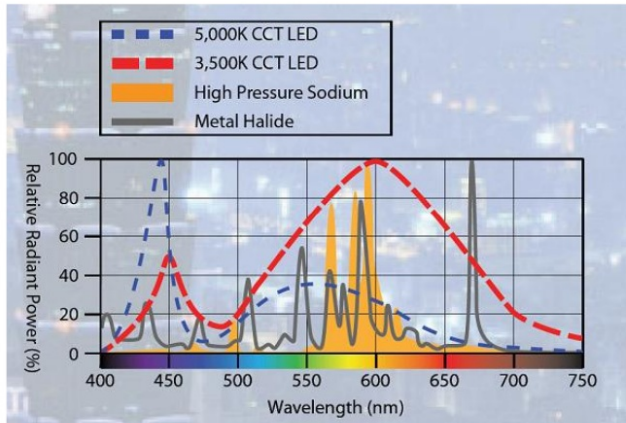


Figure 4: International Dark Sky Association, 'Warm white LEDs under 3,500K CCT emit a smaller fraction of their energy in the blue portion of the spectrum,' from 'Seeing Blue' in *Nightscape*, #80 (2010).

The growing amount of blue-rich light present in nighttime environments has increasingly been a subject of scientific research. In a detailed review of this subject, the Royal Society Te Apārangī (of New Zealand) examines findings of numerous studies focused on understanding the effects such light has on wildlife, human health, and astronomical observations.²⁷ The authors conclude that due to increasing evidence of harmful effects of such light, 'amber or warm white sources' should be given preference for use in exterior lighting applications and argue that additional research on 'the impact of artificial blue light exposure' must be

²⁷ Royal Society Te Apārangī, *Blue Light Aotearoa*.

conducted.²⁸ Similarly, in a white paper from the American Medical Association, the Council on Science and Public Health recommends 'minimizing and controlling blue-rich environmental lighting by using the lowest emission of blue light possible' in order to reduce adverse effects for both humans and the environment.²⁹ Thus, based on scientific research findings alone, there is good cause to critically examine the widespread proliferation of blue-rich, high CCT LEDs, and to consider lighting options which minimize undesirable consequences.

However, in contrast to the growing body of work coming from the sciences, comparatively little research has been done which delves into topics such as the role of dark skies in human well-being or examining the process of community lighting changes.³⁰ A number of scholars interested in advancing research on lighting and light pollution from humanities or social science perspectives have noted the current lack of work addressing such issues. Ada Blair argues that, though a great deal of attention has been devoted to studying the beneficial impacts of spending time in natural, Earth-based environments, 'Within recent times, the sky has not been considered to be part of nature,' and she observes the lack of research examining effects dark skies may have on well-being.³¹ In regard to understanding the various aspects involved in lighting initiatives, Katharina Krause notes, 'Yet, despite the growing body of literature on the "changing landscape of urban light planning" (Schulte-Römer, 2011), there has thus far been little detailed empirical work in the process of change in local lighting policies.'³² In particular, Dietrich Henckel and Timothy Moss remark, 'Very little attention has been paid as

²⁸ Royal Society Te Apārangi, *Blue Light Aotearoa*, pp. 21-22.

²⁹ Council on Science and Public Health, *Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting*, CSPH Report 2-A-16, (American Medical Association, 2016), p. 5.

³⁰ For example, much of the research listed on the ALAN Research Literature Database is science-focused. See Artificial Light at Night (ALAN) Research Literature Database, <<http://alandb.darksky.org/>> [accessed 2 August 2020].

³¹ Ada Blair, *Sark in the Dark: Wellbeing and Community on the Dark Sky Island of Sark* (Ceredigion, Wales: Sophia Centre Press, 2016), p. 33 & 38.

³² Katharina Krause, 'Regulating Urban Lighting: Prospects for Institutional Change,' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), p. 125.

yet to lighting in cities of the Global South or rural communities in general,' and they discuss the need for in-depth studies of lighting in communities of various sizes and in diverse locales.³³ Thus, it is evident that case studies and other research addressing social dimensions of lighting are called for in this emerging subject area.

To my knowledge, aside from my research presented in this dissertation, there have not been any other case studies on 'dark sky friendly' streetlight retrofits which address details of the lighting chosen, examine community processes necessary for the project to come to fruition, and delve deeply into the thoughts and experiences of community members involved with and affected by the retrofit. This may be partially due to the multi-disciplinary approach of such research, the fact that the advent of 'Dark Sky Studies' as distinct area of academic research is a new phenomenon, and the relatively recent emergence of LEDs into outdoor lighting uses. Additionally, LEDs with substantially reduced blue light content and other attributes enhancing their 'dark sky friendly' status were not widely available when LEDs first began to be utilized in such applications. Thus it has been only fairly recently that research into the phenomenon of 'dark sky friendly LED retrofits' could be conducted. One such example is the paper published by John Barentine *et al* in 2018 which concluded that Tucson, Arizona's conversion to 3000 K LED streetlights resulted in a 7% reduction in skyglow. This study was a scientific paper focused on the measurement of skyglow, so it did not address details of the processes that led to the retrofit nor the community's experiences with the new lighting.³⁴

However, preliminary work seeking to better understand the human elements in the context of lighting has been done in related areas. The volume, *Urban Lighting, Light Pollution and Society* contains a collection of papers which seek to

³³ Dietrich Henckel and Timothy Moss, 'Towards a Brighter Future? Conclusions for Lighting Research and Policy,' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), p. 301.

³⁴ John C. Barentine, Constance E. Walker, Miroslav Kocifaj, František Kundracik, Amy Juan, John Kanemoto, and Christian K. Monrad, 'Skyglow Changes Over Tucson, Arizona, Resulting From A Municipal LED Street Lighting Conversion,' *Journal of Quantitative Spectroscopy and Radiative Transfer*, 212, (2018), pp. 10-23.

address the under-researched area of social dimensions of outdoor lighting.³⁵ As Dietrich Henckel and Timothy Moss describe in the book's conclusion, this book 'presents one of the first state-of the art overviews of current debates on lighting among the humanities and social sciences.'³⁶ Several of the papers in this book present research pertinent to mine. In 'Designating Dark Sky Areas: Actors and Interests,' Josiane Meier discusses her findings of three case studies of 'dark sky places.'³⁷ In her work, Meier sought to identify key categories of actors involved with dark sky designations and to ascertain central reasons for interest in this issue for each group.³⁸ She concludes that the creation of such dark sky regions is 'dependent on the support of a multitude of stakeholders at local and regional levels,' and found that 'all identified actors see pre-existing interests of theirs matched by potential benefits resulting from the designation.'³⁹ In this research, she found that such interests were complimentary to one another, and created 'win-win situations.'⁴⁰

In 'Residents' Perceptions of Light and Darkness,' Anja Besecke and Robert Hänsch describe results of their research involving the distribution of questionnaires in order to learn about public opinion of lighting changes in several areas near Berlin.⁴¹ Similar to the observations of other academics engaged in social science based lighting research, they note that, due to lack of investigation

³⁵ Josiane Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (eds), *Urban Lighting, Light Pollution and Society*, (New York, NY: Routledge, 2015).

³⁶ Dietrich Henckel and Timothy Moss, 'Towards a Brighter Future? Conclusions for Lighting Research and Policy,' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane, Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), p. 300.

³⁷ Josiane Meier, 'Designating Dark Sky Areas: Actors and Interests,' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane, Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), pp. 177-196.

³⁸ Josiane Meier, 'Designating Dark Sky Areas: Actors and Interests,' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane, Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), p. 184.

³⁹ Meier, 'Designating Dark Sky Areas: Actors and Interests,' p. 193 & 191.

⁴⁰ Meier, 'Designating Dark Sky Areas: Actors and Interests,' p. 191.

⁴¹ Anja Besecke and Robert Hänsch, 'Residents' Perceptions of Light and Darkness' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane, Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), pp. 224-248.

into this subject, 'the overall knowledge about residents' perceptions of artificial outdoor lighting in general is still very limited.'⁴² In their research, they sought to examine residents' perceptions of LED lighting installed in their communities in 2011 and 2012. The CCT of the new fixtures ranged from 3000 K to 4000 K, thus they emitted much more light in the blue part of the spectrum and produced a 'whiter' light than the 2200 K 'dark sky friendly' retrofit I examine in this dissertation.⁴³ Among Besecke and Hänsch's findings were that suburban residents were more acutely aware of changes in visibility of the stars than those in urban locales and that overall, residents were satisfied with the new lighting.⁴⁴ However, they noted that 18-25% (depending on the particular region under study) of respondents found the new LED fixtures to be 'bright' or 'too bright'.⁴⁵ In their discussion of areas for future research, the authors noted the 'lack of information on the views of the rural population,' on lighting and light pollution, an issue this dissertation seeks to help address.⁴⁶

In the ebook, *Light Pollution - A Global Discussion*, several dimensions of outdoor lighting are discussed and attention is given to recent LED streetlight installations and the issue of color temperature.⁴⁷ This book is divided into two main sections, with each highlighting the results of a separate research endeavor. In the first section, the authors present the results of their exploration into three topics - the protection of dark skies, color temperature of lighting, and legal aspects of lighting policy. For each of these discussions, the authors conducted interviews with a handful of individuals considered to be 'experts' in an area relevant to the subject under discussion, and the interviewees shared their professional recommendations and personal experiences regarding that topic. In the second section, the authors present the results of their 'global expert survey,' the aim of

⁴² Besecke and Hänsch, 'Residents' Perceptions of Light and Darkness,' p. 225.

⁴³ Besecke and Hänsch, 'Residents' Perceptions of Light and Darkness,' p. 228.

⁴⁴ Besecke and Hänsch, 'Residents' Perceptions of Light and Darkness,' p. 246 & 245.

⁴⁵ Besecke and Hänsch, 'Residents' Perceptions of Light and Darkness,' p. 244.

⁴⁶ Besecke and Hänsch, 'Residents' Perceptions of Light and Darkness,' p. 247.

⁴⁷ Nona Schulte-Römer, Etta Dannemann, and Josiane Meier, *Light Pollution - A Global Discussion* (Leipzig, Germany: UFZ Helmholtz Centre for Environmental Research, 2018).

which was to assemble the views of those engaged with lighting and light pollution issues in order to 'collect examples of lighting conflicts and best practices,' and to ascertain possible ways forward.⁴⁸ The authors argue that, in addition to continuing scientific research in this subject area, it is also essential to address cultural aspects of lighting and note that it is 'a political issue that calls for public debate, democratic deliberation, balanced decision-making and innovative solutions.'⁴⁹

Several authors have addressed aspects of the human connection to dark skies. In her research, Ada Blair explores the relationship residents of the 'Dark Sky Island' of Sark have with the night sky. She found evidence that dark skies can indeed enhance well-being and argues that additional research is needed to address 'the missing sky factor' in the health and psychology fields.⁵⁰ Though much of his work is focused on Earth-based nature, Richard Louv, who coined the term 'nature deficit disorder' to refer to adverse effects associated with lack of contact with the natural world, recently addressed the issue of the value of human connection with the natural night sky in an interview with the IDA.⁵¹ The importance of personal connections with the night sky is a subject astronomer Tyler Nordgren discusses, arguing that the photos taken by space telescopes are not sufficient to facilitate an emotional connection between people and the larger universe, noting, 'in their hearts they recognize there is still something unspeakably special about seeing it with their own eyes.'⁵² The work of authors such as these suggests that the ability to experience the night sky firsthand is something of value and should be considered an issue of significance in the context of lighting and light pollution discussions.

⁴⁸ Schulte-Römer, Dannemann, and Meier, *Light Pollution - A Global Discussion*, p. 170.

⁴⁹ Schulte-Römer, Dannemann, and Meier, *Light Pollution - A Global Discussion*, p.16.

⁵⁰ Ada Blair, *Sark in the Dark: Wellbeing and Community on the Dark Sky Island of Sark* (Ceredigion, Wales: Sophia Centre Press, 2016), p. 147.

⁵¹ Richard Louv, *Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder* (Chapel Hill, NC: Algonquin Books of Chapel Hill, 2005), p. 34; Richard Louv, 'Childhood and the Night' (talk presented on 21 April 2020 at the IDA's International Dark Sky Week 2020 online event, April 19-26 2020), <<https://idsw.darksky.org/schedule/>> [accessed 21 April 2020].

⁵² Tyler Nordgren, *Stars Above, Earth Below: A Guide to Astronomy in the National Parks* (Chichester, UK: Praxis, 2010), p. 425.

In addition to academic publications, there is a small, but slowly growing collection of work addressing dark skies and light pollution aimed towards a broader audience, such as those drawn to amateur astronomy, natural history, or engaging with dark sky issues. Among these are the IDA's, *Fighting Light Pollution: Smart Lighting Solutions for Individuals and Communities*, a short, full-color introduction to light pollution for those interested in 'efficient and effective lighting and preserving the night sky' and *The End of Night*, Paul Bogard's firsthand account of his travels to locales with varying degrees of nighttime darkness, as well as his meetings with a diverse array of people engaged with light pollution issues.⁵³ There are also a few short films about light pollution, such as *Saving the Dark*, a documentary which delves into scientific research about implications of ALAN and draws upon interviews with researchers and others knowledgeable about dark sky issues.⁵⁴ Though light pollution is still not widely known about or discussed outside of the astronomical community, there are gradually becoming more resources available which can engage the wider public with this issue.⁵⁵

⁵³ International Dark-Sky Association, *Fighting Light Pollution* (Mechanicsburg, PA: Stackpole Books, 2012), back cover; Paul Bogard, *The End of Night: Search for Natural Darkness in an Age of Artificial Light* (London: Little Brown and Company, 2013).

⁵⁴ *Saving the Dark*, dir. by Sriram Murali, (2018).

⁵⁵ For example, see the children's book by Joan Marie Galat, *Dark Matters: Nature's Reaction to Light Pollution* (Markham, Ontario: Red Deer Press, 2017); National Optical Astronomy Observatory, *Quality Lighting Teaching Kit*, <<https://www.noao.edu/education/qltkit.php>> [accessed 30 August 2020]; the citizen science initiative, Globe at Night, <<https://www.globeatnight.org/>> [accessed 12 September 2020].

Chapter 3: Methodology

This research project is focused on a case study examining a dark sky friendly LED streetlight retrofit and the thoughts of community members about lighting and dark skies in the community of Stanley. According to John Biggam, the goal of a case study 'is to probe deeply and to analyze intently the multifarious phenomena that constitute the life cycle of the unit;' he notes that 'the primary justification for a case study is to explore some contemporary issue *in depth*.'⁵⁶ (Biggam's italics) A case study fits my desired research aims well, as it allows for a thorough study and enables me to uncover and examine many of the nuances associated with the implementation of this streetlight retrofit, as well as to obtain a deeper understanding of the thoughts of local residents on dark sky issues in Stanley.

In this research, I conducted semi-structured interviews and reviewed relevant primary and secondary source material. As Judith Bell observes, utilizing such an interview format gives 'freedom to allow the respondents to talk about what is of central importance to them,' while also retaining 'some loose structure to ensure all topics which are considered crucial to the study are covered.'⁵⁷ In addition, I distributed a brief electronic questionnaire to Stanley-area residents focused upon soliciting their thoughts about dark skies and their recent LED streetlight retrofit. Monique Hennick *et al* discuss the usefulness of a mixed methods approach, as does Alan Bryman, while Bell notes, 'Case studies . . . can combine a wide range of methods.'⁵⁸ Many 'dark sky' researchers have utilized mixed research methods. For example, in her study of actors and interests of those involved with the creation of dark sky places, Josiane Meier used 'case studies centered on semi-structured interviews' and also engaged in 'reviews of primary and secondary literature, participant observation, policy document analysis and screening of media

⁵⁶ John Biggam, *Succeeding With Your Master's Dissertation: A Step-By-Step Handbook*, 3rd edn (Berkshire, England: Open University Press, 2015), p.151.

⁵⁷ Judith Bell, *Doing Your Research Project: A guide for first-time researchers in education, health and social science*, 5th edn (Berkshire, England: Open University Press, 2010), p. 165.

⁵⁸ Monique Hennick, Inge Hutter, and Ajay Bailey, *Qualitative Research Methods* (London: Sage Publications, 2011), pp. 52-58; Alan Bryman, *Quantity and Quality in Social Research* (London & New York: Routledge, 1988), pp. 137-140; Bell, *Doing Your Research Project*, p. 117.

reports.⁵⁹ Ada Blair also utilized an analogous approach in her research on the dark sky island of Sark, as she sought to obtain a detailed understanding of the role the dark night sky played in the lives of residents of the island via 'interviews, the focus groups, my reflexive journal, and various e-mails'.⁶⁰ In their research focused on various stakeholders' perceptions of light pollution, Nona Schulte-Römer *et al* utilized both interviews and a survey to gain insight into the thoughts of those engaged with these issues, while Anja Besecke and Robert Hänsch used a detailed questionnaire to learn about Berlin-area residents' thoughts about lighting, darkness, and newly-installed LED streetlights.⁶¹ Thus there is a precedent of using approaches similar to mine to learn about the activities and experiences of those involved with dark skies.

I chose to utilize in-depth interviews as a primary means of gathering data for several reasons. First, many of my interviewees were highly involved in aspects of dark sky initiatives in this region: conducting interviews would allow me to ask for further details or to clarify information if needed. Second, the use of interviews would enable me to adjust the focus of my questions when necessary, to areas in which the interviewees were more knowledgeable or had more to say. Third, the interview format would allow greater freedom for interviewees to bring up topics they felt were important. Finally, the use of interviews would facilitate a greater degree of spontaneity and would enable me to glimpse interviewees' individual personalities and unique characteristics. As Hennick *et al* observe, 'in-depth interviews are thus primarily used when you seek to capture people's individual

⁵⁹ Josiane Meier, 'Designating Dark Sky Areas: Actors and Interests', in *Urban Lighting, Light Pollution and Society*, ed. by Josiane, Meier, Ute Hasenöhrl, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), p. 177.

⁶⁰ Ada Blair, *Sark in the Dark: Wellbeing and Community on the Dark Sky Island of Sark* (Ceredigion, Wales: Sophia Centre Press, 2016), p. 98.

⁶¹ Nona Schulte-Römer, Etta Dannemann, and Josiane Meier, *Light Pollution -a Global Discussion*, (Leipzig, Germany: UFZ Helmholtz Centre for Environmental Research, 2018); Anja Besecke and Robert Hänsch, 'Residents' Perceptions of Light and Darkness' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane, Meier, Ute Hasenöhrl, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), pp. 224-248.

voices and stories,' which was precisely my aim in this research.⁶² (Hennick's italics)

To find and connect with potential interviewees, I utilized what Hennick *et al* refer to as 'snowball recruitment' or 'chain sampling,' which involves asking interviewees if they have recommendations of additional interviewees whom the researcher might wish to interview.⁶³ This method of recruitment, note Hennick *et al*, 'is particularly suitable for identifying study participants with very specific characteristics . . . who may be difficult to identify with other recruitment methods.'⁶⁴ In selecting individuals to interview, I sought to connect mainly with those who had been highly involved with Stanley's streetlight retrofit or other dark sky initiatives in the area, as I wanted to gain a deeper understanding of the experiences and actions of those most involved with these processes. Thus, I found the 'snowball recruitment' method to be most appropriate for locating most of my interviewees.

My initial contact for the region was the CEO of Lumican (the company providing the fixtures for Stanley's streetlight retrofit), whom I met at a dark sky conference. He later introduced me to the mayor of Stanley, who in turn introduced me to individuals he knew were involved with dark sky issues in the community. I interviewed a total of eight individuals for this research. Seven were residents of Stanley or the surrounding area (outside city limits but still having a 'Stanley' address), and one was the CEO of Lumican. My Stanley interviewees included the town's mayor, three individuals with a long history of engagement with dark skies preservation in the area, a teacher at the local grade school, and two residents who were not active in dark skies advocacy but expressed appreciation for the area's dark skies. All interviewees were recruited using the 'snowball' method, except for the two individuals not as involved with

⁶² Hennick, Hutter, and Bailey, *Qualitative Research Methods*, p. 110.

⁶³ Hennick, Hutter, and Bailey, *Qualitative Research Methods*, p. 100.

⁶⁴ Hennick, Hutter, and Bailey, *Qualitative Research Methods*, p. 100.

dark sky issues. These were people I met during my time in Stanley who agreed to be interviewed in order to give a 'lay person's' perspective on the topic.

Each of my interviewees was given an explanation of the purpose of this research and each signed a release form. All except two were fine with their real names being used in my research. However, I have opted against using interviewees' names in this paper. At the beginning of each interview, I asked if it was okay if I recorded our conversation with a voice recorder; all indicated that this was acceptable to them. Six of my eight interviews were conducted in person while I was in Stanley. The other two were conducted via telephone after I returned from Idaho, as those individuals were not present in Stanley while I was there. These were all individual interviews, except those that were with a husband and wife, in which case, I conducted the interview with both individuals simultaneously.

My interviews focused upon three general themes: the nature of interviewees' involvement with dark sky issues, their perception of dark sky initiatives' effects on the larger community, and their personal thoughts and feelings about dark skies. Like Ada Blair, I sought to learn more about my interviewees' experiences living in a place with dark skies and to find out how looking at the night sky made them feel.⁶⁵ Some of my areas of inquiry were more closely aligned with topics Schulte-Römer *et al* focused on, such as learning the reasons why many of my interviewees believed dark skies were important, what challenges they had experienced during the course of their efforts to raise awareness of this issue in their community, and what factors they believed were essential for the dark sky initiatives in their area to be successful.⁶⁶ As in Meier's study, I sought to understand the underlying motivations fueling interviewees' engagement with dark sky initiatives.⁶⁷ Tyler Nordgren has observed that the ability to experience a starry night sky firsthand appears to be an important factor in determining whether people will actually take interest in and care about the night sky, so I was also interested in exploring what

⁶⁵ Ada Blair, *Sark in the Dark*, p. 149-150.

⁶⁶ Schulte-Römer, Dannemann, and Meier, *Light Pollution - A Global Discussion*, pp.169-216.

⁶⁷ Meier, 'Designating Dark Sky Areas: Actors and Interests.'

role personal experiences with the night sky might play in fueling the efforts of dark sky advocates in Stanley.⁶⁸ Similar to Schulte-Römer *et al*'s approach in their 'expert discussions,' when I spoke with individuals who were involved with technical details and other specifics pertaining to Stanley's streetlights, the focus of the conversation tended to be more centered around these subjects.⁶⁹

While I endeavored to obtain an in-depth understanding of the thoughts and actions of those most involved with dark sky advocacy in my interviews, in distributing an online questionnaire, my goal was to solicit responses from the community more broadly, aiming to gain insight into their thoughts and feelings about dark skies as well as their feedback on the new streetlights. As Hennick *et al* note, the use of interviews followed by a questionnaire allows for qualitative findings to be 'quantified' and enables the researcher to gain insight into the thoughts of the larger population.⁷⁰ As in Besecke and Hänsch's study, I sought to understand residents' perceptions of the illuminance levels and other attributes of the lights, as well as whether they found that the new lighting enhanced or diminished their view of the stars.⁷¹ My method for distributing the electronic questionnaire to Stanley residents was somewhat similar to that of my interviewee selection: after returning home, I e-mailed Stanley-area interviewees the link to the questionnaire and asked if they could share the link with anyone else they knew in Stanley who might be willing to take a few minutes to complete it. When e-mailing the survey link, I made a point to mention that I was interested in *all* community feedback, not just from people who were enthusiastic about dark skies. Given that I only received a response from two of my interviewees that they would complete and distribute this survey, it is possible that only two of my questionnaire respondents were also interviewees. The mayor of Stanley indicated he would share my questionnaire link with Stanley-area residents who had previously

⁶⁸ Tyler Nordgren, *Stars Above, Earth Below: A Guide to Astronomy in the National Parks* (Chichester, UK: Praxis, 2010).

⁶⁹ Schulte-Römer, Dannemann, and Meier, *Light Pollution - A Global Discussion*, pp. 31-168.

⁷⁰ Hennick, Hutter, and Bailey, *Qualitative Research Methods*, p.57.

⁷¹ Besecke and Hänsch, 'Residents' Perceptions of Light and Darkness,' pp. 233-234 & 236-238.

requested to be on an e-mail list informing them of city activities which might be of interest or otherwise affect them.

The questionnaire consisted of 15 questions organized into two sections (the first focused on the new streetlights; the second was about dark skies) and consisted of 10 multiple choice and 5 free-response questions. Prior to completing the electronic questionnaire, participants were provided with a brief explanation of this research and were informed that by completing this questionnaire, they were consenting to their data being used in my research, yet they would remain anonymous. Participants needed to check a box stating, 'I Agree' to begin the survey.

In addition to conducting interviews, while in Idaho, I sought out primary source documents that could be more challenging to locate remotely. I stopped at Forest Service and tourist information centers to pick up brochures and magazines about the local area. I had originally planned to arrive early enough in Stanley to be able to see the old fixtures before their replacement and stay in town through the installation of the new ones. However, due to a number of logistical challenges and the fact that the installation date (determined by the utility) changed numerous times, this was not possible. Consequently, my week-long trip concluded about a week and a half prior to the complete lighting switch-out.

Reflexive Considerations

Hennick *et al* observe that 'study participants reflect their subjective views of the social world and that researchers also bring their subjective influences to the research process.'⁷² It is therefore necessary for the researcher to engage in reflexivity, or 'conscious self-reflection' and to consider one's position as an 'insider' or an 'outsider' in context of the group one is studying.⁷³ Sonya Corbin Dwyer and Jennifer Buckle consider the 'insider/outsider' issue at length, noting, 'there are costs and benefits to each status.'⁷⁴ However, they argue that this 'dichotomy' may be overly simplistic, note the impossibility of a researcher 'fully occupy[ing]' either category, and consider the existence of a 'space between that allows researchers to occupy the position of both.'⁷⁵ I am somewhat of an insider to the dark sky activist community, as I have been a member of the IDA for several years and have attended meetings and conferences focused upon dark skies and light pollution. The abatement of light pollution and the preservation of starry night skies is of personal importance to me, and I have given numerous talks at a variety of places (such as museums, parks, and planetariums) about astronomy, light pollution, and dark skies. However, I am an outsider to the community I am researching, as, prior to this research, I had not been to Idaho, nor had I interacted with any of my interviewees who live in that region. Before my interview with the CEO of Lumican, I had communicated with him on multiple occasions, inquiring about lighting installations he had been involved with and requesting documents containing detailed technical information about his company's light fixtures. Thus, it seems that in my relationship to this research, I occupy what Corbin Dwyer and Buckle describe as 'a third space, a space between.'⁷⁶

⁷² Monique Hennick, Inge Hutter, and Ajay Bailey, *Qualitative Research Methods* (London: Sage Publications, 2011), p. 19.

⁷³ Hennick, Hutter, and Bailey, *Qualitative Research Methods*, p. 18 & 19.

⁷⁴ Sonya Corbin Dwyer and Jennifer L. Buckle, 'The Space Between: On Being an Insider-Outsider in Qualitative Research,' *International Journal of Qualitative Methods*, 8(1) (2009), p. 57.

⁷⁵ Corbin Dwyer and Buckle, 'The Space Between,' p. 62, 61, & 54.

⁷⁶ Corbin Dwyer and Buckle, 'The Space Between,' p. 60.

Chapter 4: Findings

The Central Idaho Dark Sky Reserve and Communities: the Place

Idaho is in the northwestern United States, and the Central Idaho Dark Sky Reserve (CIDSr) is located in the central part of the state (see figs. 5 and 6). The reserve is 1,416 square miles (906,000 acres) in area, containing 5 communities, some private land, and vast tracks of public land (see fig. 7).⁷⁷ Much of the terrain is mountainous and forested, and the region is home to a great variety of flora and fauna (see fig. 8). The U.S. Forest Service manages the majority of the public land in the CIDSr. A large portion of the reserve is contained within the 756,000 acre Sawtooth National Recreation Area (NRA), which contains 'nearly 1,000 miles of rivers and streams, more than 1,100 lakes, and more than 40 peaks towering over 10,000 feet.'⁷⁸ The Sawtooth NRA was created in 1972 'to assure the preservation and protection of the natural, scenic, historic, pastoral and fish and wildlife values and to provide for the enhancement of the recreation values associated (t)herewith . . .'⁷⁹ Within the NRA are three wilderness areas. Though the purpose of the NRA is dually focused on maintaining healthy ecosystems and creating opportunities for humans to recreate in the region, the wilderness areas are managed somewhat differently. The U.S.'s Wilderness Act of 1964 provides a definition of such places: 'A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammelled by man, where man himself is a visitor who does not remain.'⁸⁰ Accordingly, in wilderness areas, land management activities are kept to a minimum, motorized vehicles are prohibited, and human impacts are

⁷⁷ Central Idaho Dark Sky Reserve, *Central Idaho Dark Sky Reserve* (Brochure and map), 2018.

⁷⁸ U.S. Forest Service, Sawtooth National Recreation Area, and Sawtooth Interpretive & Historical Association, *Hiking, Biking, Motorcycle & Horseback Trails in the Sawtooth National Recreation Area*, Map and Trail Information, (Maps by E.B. Phipps, May 2018).

⁷⁹ 'Sawtooth National Recreation Area Act,' Section 1, P.L. 92-400, Enacted 22 August 1972, <https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5176190.pdf> [accessed 24 September 2020].

⁸⁰ 'Wilderness Act,' Section 2, P.L. 88-577, Enacted 3 September 1964, <<https://www.govinfo.gov/content/pkg/STATUTE-78/pdf/STATUTE-78-Pg890.pdf>> [accessed 24 September 2020].

minimized as much as possible.⁸¹ Thus the CIDSr consists mostly of lands which are quite wild and rural in nature, and due to their distance from large population centers, they have very dark skies.



Figure 5: Idaho in the U.S. *Image: Wikipedia.*

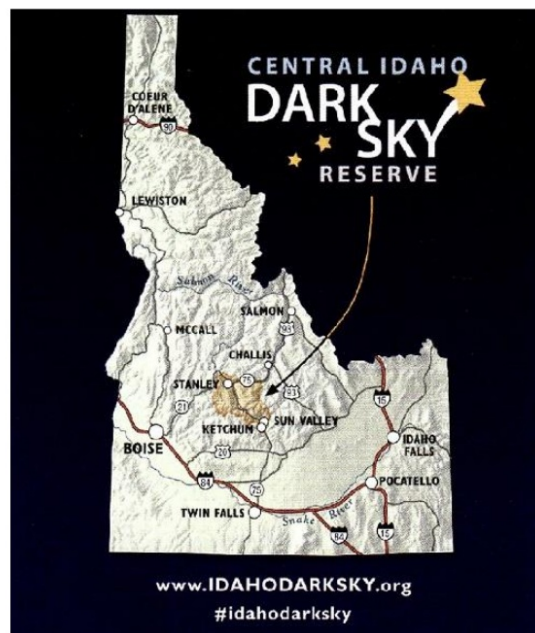


Figure 6: Central Idaho Dark Sky Reserve. *Image: Central Idaho Dark Sky Reserve.*

⁸¹ U.S. Forest Service, 'Sawtooth Wilderness' informational brochure (No year given).

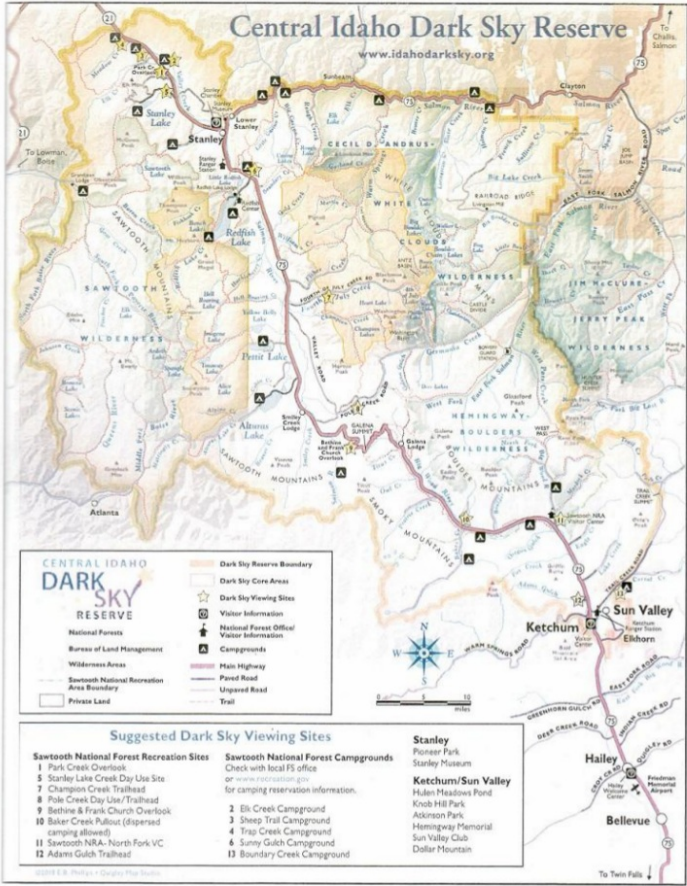


Figure 7: Detailed Map of Central Idaho Dark Sky Reserve. *Image:* Central Idaho Dark Sky Reserve.



Figure 8: An example of terrain common in CIDSr. Scenic overlook south of Stanley on Hwy 75. 31 October, 2019. Photo: Jessica Heim.

On the southeastern edge of the reserve are the communities of Sun Valley (population 1,406) and Ketchum (population 2,689), the largest population centers in the reserve (see fig. 7).⁸² These communities boast a wide variety of amenities typically found in larger cities: public transit, libraries, eclectic dining options, arts and cultural events, and many non-profit organizations and charities.⁸³ Tourism is highly important for the economies of both Sun Valley and Ketchum, and they are well-known for their diverse summer and winter outdoor recreation opportunities.⁸⁴ In the northwest part of the reserve is Stanley (population 63) (see fig. 9). Though its year-round resident population is low, the community overflows with tourists during the summer.⁸⁵ In contrast to upscale Ketchum and

⁸² Central Idaho Dark Sky Reserve Application, (Approved by the International Dark Sky Association in December 2017), p. 6.

⁸³ Names and Numbers: Five Star Phone Books!, *Sun Valley 2019 Phone Book* (Sun Valley, ID: K.W. Brock Directories, Inc., 2018).

⁸⁴ Central Idaho Dark Sky Reserve Application, p. 19.

⁸⁵ For example, see Stanley Inn, *Why you should stay at the Stanley High Country Inn this winter in Stanley, Idaho!* <<https://stanleyinn.com/blog/why-you-should-stay-at-the-stanley-high-country->

Sun Valley, Stanley exudes an Old West frontier vibe, apparent in both its architecture and the independent attitude common among the area's residents (see figs. 10 and 11). It is situated at the convergence of three scenic byways and is on the banks of the Salmon River. A variety of rafting companies and outfitters (typically small businesses that assist visitors with planning and packing for short and long duration front and backcountry trips and often offer guided excursions) operate in the Stanley area, and all manner of outdoor activities are highly popular during the summer months. There are a plethora of lodging options and local businesses catering to outdoor enthusiasts' needs. In fact, the 2019 edition of the Stanley area business directory has 105 entries.⁸⁶



Figure 9: Entering Stanley from Hwy 21. 2 November 2019. Photo: Jessica Heim.

[inn-this-winter-in-stanley-idaho](#) [accessed 20 September 2020]. This observation was also made by many of my interviewees.

⁸⁶ Stanley-Sawtooth Chamber of Commerce, *Stanley-Sawtooth Chamber of Commerce Business Directory*, 2019 edition.



Figure 10: Stanley, as viewed from Stanley School. 2 November, 2019. *Photo: Jessica Heim.*



Figure 11: An example of Stanley's rustic street signs. 2 November, 2019. *Photo: Jessica Heim.*

However, unlike Ketchum and Sun Valley, Stanley does not experience a high volume of tourists during the winter months.⁸⁷ This is due in large part to the fact that it is considerably more difficult to travel to Stanley at such times. Coming from Hailey (which has the closest airport), one must drive for 75 miles and go over Galena pass, where the road curves sharply into snakelike switchbacks winding their way up the mountain. Coming from the state's capital, Boise, one must drive over similarly difficult mountain terrain for nearly double the distance; according to one of my interviewees, this is the most treacherous winter drive in the state. Additionally, Stanley gets extremely cold in the winter; it is known as the coldest winter location in the contiguous U.S., and its average winter snowfall is 75 inches (1.9 meters).⁸⁸ It has an average of 60 days a year below 0° F (-18° C), and its record low temperature was -54° F (-48° C).⁸⁹ Thus only the most dedicated outdoor enthusiasts (mostly snowmobilers, according to Stanley's mayor) travel to Stanley in the winter, and the vast majority of Stanley's businesses close down for the season. To thrive in Stanley during the off-season, one must be highly self-sufficient and enjoy solitude.

⁸⁷ For example, see Stanley Inn, *Why you should stay at the Stanley High Country Inn this winter in Stanley, Idaho!* <<https://stanleyinn.com/blog/why-you-should-stay-at-the-stanley-high-country-inn-this-winter-in-stanley-idaho>> [accessed 20 September 2020]. This observation was also made by many of my interviewees.

⁸⁸ Central Idaho Dark Sky Reserve Application, p. 15; Weatherbase, *Stanley, Idaho, Monthly - All Weather Averages*, <<https://www.weatherbase.com/weather/weatherall.php3?s=676801&cityname=Stanley%2C+Idaho%2C+United+States+of+America&units=>>> [accessed 24 September 2020].

⁸⁹ Weatherbase, *Stanley, Idaho, Monthly - All Weather Averages*, <<https://www.weatherbase.com/weather/weatherall.php3?s=676801&cityname=Stanley%2C+Idaho%2C+United+States+of+America&units=>>> [accessed 24 September 2020].

Stanley's Earlier LED Retrofits

The community of Stanley has been involved with changing its lighting to help protect dark skies for many years. Stanley's 2010 Comprehensive Plan mentions the importance of dark skies and indicates that all exterior light fixtures need to be shielded.⁹⁰ In this document, the city officials assert: 'Stanley and the surrounding area enjoy one of the best night sky environments in the nation. The surrounding wilderness areas assure darkness in those areas. Within the city the night sky is to be preserved and enhanced to the benefit and enjoyment of our residents and visitors alike.'⁹¹ Thus the idea of utilizing lighting which better preserves the nighttime environment is not only an idea advocated by many Stanley area residents - it is also a tenet in the city's official planning guidelines.

Prior to the 2019 retrofit, the city of Stanley had installed LED streetlights that were considered 'dark sky friendly' twice previously. During my interview with him, I asked Stanley's mayor to share his experiences with and perspectives on Stanley's history with these streetlight retrofits, as he has been highly involved with these initiatives for many years. He noted, 'we started this project of converting, shielding our streetlights . . . well before we started the effort for the Dark Sky Reserve here. So we were just doing that because we thought it was a good idea to convert the streetlights at that time.' He discussed the earlier streetlight retrofits in detail. One kind of light was installed in 2012; another variety was installed in 2015. At the time of my visit, Stanley had three different types of streetlights present: those installed in both 2012 and 2015 and one newly installed fixture - the pilot for the upcoming 2019 retrofit. In November 2019, all fixtures from previous retrofits were to be replaced with the new variety. In order to understand the context of the 2019 retrofit and to gain a fuller understanding of why the community chose to retrofit its lights yet again, a brief examination of Stanley's previous streetlights is in order.

⁹⁰ City of Stanley, 'Comprehensive Plan,' Adopted 12 August 2010, pp. 14 and 15.

⁹¹ City of Stanley, 'Comprehensive Plan,' pp. 14 and 15.

The mayor of Stanley provided me with images and technical specifications of all four of the streetlight varieties present in Stanley during the past decade and shared many details about these earlier lighting projects. Prior to the 2012 retrofit, Stanley had High Pressure Sodium (HPS) lamps which produced relatively warm light (2100 K) and were unshielded, so the light went in all directions (see fig. 12). These were replaced in 2012 with cool white LED lamps which emitted much blue light (6500 K) and were shielded to reduce light going sideways and upwards (see figs. 13, 14, and 15). These were installed relatively early in the context of LED streetlight retrofits, when high Kelvin, extremely blue-rich LEDs were the only kind available. As the mayor noted, 'those . . . were considered dark sky compliant according to the IDA guidelines at the time. . . . that was kind of what the technology was then.' The fixtures installed in 2015 (replacing two lamps from the 2012 retrofit which had failed) were also shielded, but unlike the previous installation, these were much warmer in color (3000 K), thus they contained markedly less blue light than the earlier 'generation' (see figs. 16 and 17).



Figure 12: Sylvania 100 Watt, High Pressure Sodium, unshielded, 2100 Kelvin, 9500 lumens, in Stanley, Idaho. Installed pre-2012. *Photo: Mayor of Stanley.*



Figure 13: Clearlight 40 Watt, LED, shielded, 6500 Kelvin, 2100 lumens, in Stanley, Idaho. Installed in 2012. *Photo: Mayor of Stanley.*



Figure 14: Daytime photograph of Clearlight LED 6500 K lamp in Stanley, Idaho. 1 November, 2019. *Photo: Jessica Heim.*

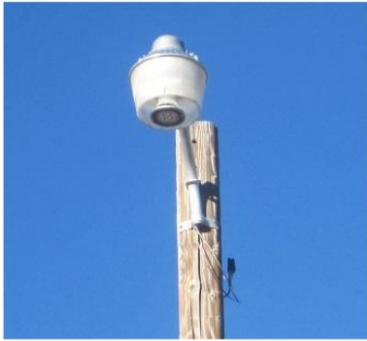


Figure 15: Daytime photograph of Clearlight LED 6500 K lamp with alternate fixture style in Stanley, Idaho. 1 November, 2019. *Photo: Jessica Heim.*



Figure 16: Evluma Areamax 40 Watt, LED, shielded, 3000 Kelvin, 3500 lumens, in Stanley, Idaho. Installed in 2015. *Photo: Mayor of Stanley.*



Figure 17: Daytime photograph of Evluma Areamax 3000 K LED fixture in Stanley, Idaho. 1 November, 2019. Photo: Jessica Heim.

For both the 2012 and 2015 retrofits, the city worked with the local utility, Salmon River Electric Cooperative, to obtain the lights. In both cases, the lamps chosen were ones the utility could obtain from suppliers they had an established relationship with. The mayor explained the process of picking out lights for these earlier retrofits:

'I discussed that with the electric company. And I told them what we were interested in doing and why we wanted to do it, because we were interested in shielding the lights. And they said, well, we have some that are dark sky compliant, at least they were at the time. And there really wasn't much discussion about color temperature or anything because at the time if you were going to buy an LED streetlight, that's kind of what you were going to get, right? And even IDA wasn't - that didn't seem to be a big concern for them back then. I think they were doing some research on that, but they were kind of stuck also because the technology just wasn't there.' (referring to the lack of availability of LED lamps with greatly reduced blue light content).

For these earlier retrofits, the mayor explained, the utility covered the costs of purchasing the fixtures. Thus, as in the past, the utility owned the lights and charged the city for the electricity needed to power them. Though the LEDs

installed in both 2012 and 2015 used substantially less electricity than the HPS lamps they replaced, the utility did not lower the city's electrical bill in kind after their installation. 'They said, we'll do all this for free,' the mayor recalled, 'You'll be using 60 percent less energy. But we're gonna keep your bill the same because we're providing this service.' 'And that was fair,' he added. So for these first two retrofits, the city did not need to cover the expense of upgrading to more energy-efficient lighting, but they did not receive any savings as a result of reducing their electrical consumption.

Though these LED fixtures were shielded, the mayor did not see them as optimal. In particular, he was concerned that the LEDs from the first generation retrofit did not light intersections well enough, due to their greatly reduced brightness, something he was working to remedy with the 2019 retrofit. In addition, there was the issue of the color temperature of these older lights - they gave off a very bluish glow. 'Those are really unacceptable now,' the mayor stated, 'I could live with the 3000 K lights, but the older ones, no.' Although the earlier retrofits addressed some aspects of reducing light pollution, it was evident that the mayor believed it was necessary to retrofit the lights again in order to solve these concerns. The changing technology of LEDs and the increasing availability of warmer colored lights were also reflected in documents issued by the city. Though Stanley's 2010 Comprehensive Plan addressed the basics of dark sky friendly lighting, it was not highly detailed, nor did it discuss color temperature.⁹² Stanley's Outdoor Lighting Resolution, adopted in 2018, gave much greater specifics to guide outdoor lighting and recommended, 'Lamps should not exceed a correlated color temperature of 3000 Kelvin.'⁹³ Thus by that point in time, it was evident that CCT was becoming an important aspect in the city's conception of 'dark sky friendly' lighting.

⁹² City of Stanley, 'Comprehensive Plan,' pp. 14 and 15.

⁹³ City of Stanley, 'Outdoor Lighting,' Resolution 2018-1, Authorized 11 January 2018.

The Creation of the Central Idaho Dark Sky Reserve

In December 2017, about two years after Stanley's 'second generation' of LED streetlights were installed, the 'Central Idaho Dark Sky Reserve' (CIDSr) was officially recognized by the IDA.⁹⁴ Though there were already many IDA dark sky places in the U.S., this was the first 'Dark Sky Reserve' in the country.⁹⁵ The establishment of this reserve was the result of the work of a large number of individuals over a long period of time. As noted in the CIDSr's press release at the time of its designation, 'The decision by IDA culminates nearly two decades of work and policy decisions by local leaders, residents and business leaders to manage and reduce the impact light pollution can have on the region's night skies and nocturnal environment.'⁹⁶ Stanley's mayor was among those involved with the creation of the reserve. As he recalled, 'I was in on the ground floor of the development of the reserve and participated in all of that. . . . It took us a couple years to prepare the application for IDA' and to figure out all the logistical elements associated with becoming a reserve. Indeed, applying to become a 'Dark Sky Reserve' recognized by the IDA is a highly involved process. Among the components of a quality application are discussion not only of the proposed reserve boundaries, but also, information on how the diverse land managers of the area will work together to maintain the area's dark skies, and it must include numerous letters of support from local community members and relevant stakeholders involved.⁹⁷ In addition, the application must contain a detailed lighting inventory of existing lighting, a lighting management plan, night sky brightness readings, and discussion of current and planned educational outreach activities.⁹⁸

⁹⁴ Central Idaho Dark Sky Reserve, 'Central Idaho Earns Designation as the Nation's First Dark Sky Reserve,' Press Release, (18 December 2017), < <https://www.darksky.org/wp-content/uploads/2017/12/CIDSr-Press-Release.pdf> > [accessed 16 September 2020].

⁹⁵ Central Idaho Dark Sky Reserve, 'Central Idaho Earns Designation as the Nation's First Dark Sky Reserve.'

⁹⁶ Central Idaho Dark Sky Reserve, 'Central Idaho Earns Designation as the Nation's First Dark Sky Reserve.'

⁹⁷ International Dark Sky Association, *International Dark Sky Reserves: International Dark Sky Reserve Program Guidelines* (June 2018).

⁹⁸ International Dark Sky Association, *International Dark Sky Reserves: International Dark Sky Reserve Program Guidelines*.

The creation of the reserve resulted in a great deal of publicity for the region, not only in the local Idahoan papers, but also in national media outlets as well, including National Public Radio, TIME magazine, and the New York Times.⁹⁹ A photograph of Idaho's dark skies graced the cover of Idaho's 2019 travel guide, along with an article about the reserve and Idaho's other dark sky places (see fig. 18). Though none could give me exact numbers, all of my Stanley interviewees indicated that the establishment of the dark sky reserve had increased tourist visits to the area and many gave anecdotal evidence of interacting with visitors who mentioned their interest in coming to the Stanley area to enjoy its starry night skies. Stanley's mayor, noting media interest in the reserve, remarked, 'we got calls from Europe and everywhere about it. . . . I still get frequent calls.' In addition, he shared a personal story about being on a train in Switzerland the previous year, where, 'this guy comes up to me cause I had on a "Stanley" hat. He said, "I went there to look at the dark sky reserve!" ' So it is apparent that news of the reserve's creation was reaching people who likely would not have thought much about the region otherwise.



Figure 18: Cover of the 2019 'Official Adventure Guide of Idaho.' Image: Visit Idaho.

⁹⁹ Central Idaho Dark Sky Reserve, 'Annual Report,' 01, (1 October 2018), p. 16.

The increased visitation and publicity surrounding the reserve was one of the factors contributing to the idea of Stanley doing yet another LED retrofit in 2019. As Stanley's mayor explained:

'being within the dark sky reserve, we wanted to have this sort of a demonstration area. I mean, we're totally surrounded by the dark sky reserve. So what better place to show what a really good state of the art shielded light looks like . . . and we're having a lot of people coming here to look at the reserve, so that's not inconsequential.'

He went on to discuss the role of the town's lighting in keeping the surrounding areas dark and thought it was important for visitors to see that that the town had made changes in its lighting in order to better maintain the dark skies of the reserve. Indeed, outreach and education opportunities about dark skies are a central component of the IDA's Dark Sky Places. In order to both receive and maintain 'Dark Sky Place' status, there must be ongoing efforts to share information about dark skies and their preservation with the general public.¹⁰⁰ Thus the creation of the Dark Sky Reserve provided additional impetus for Stanley to seek to implement current 'best practices' in dark sky friendly lighting.

¹⁰⁰ International Dark Sky Association, *International Dark Sky Reserves: International Dark Sky Reserve Program Guidelines*.

Stanley's 2019 Retrofit

Given that there was technology in existence for fixtures which were even more 'dark sky friendly' than the earlier 'generations' of retrofits, Stanley's mayor began researching various options for a possible new retrofit. In addition to talking with Salmon River Electric Cooperative about the LED options they could easily obtain through their suppliers, the mayor began to do some research on 2200 K fixtures from the lighting company, Lumican. These lights had modular, customizable shielding options and very low blue light content, features which were not available on fixtures offered through the local utility (see figs. 19 and 20). The low color temperature meant that the light would appear more amber in color, in contrast to the bluish-white light of Stanley's first retrofit and the yellow light of the second (see fig. 21). This would result in light which superficially appeared similar to older HPS technology. However, unlike HPS fixtures, which commonly have a Color Rendering Index (CRI) in the low 20's, these fixtures had a CRI of 70, meaning it would be possible to more clearly differentiate the nuances of color of objects illuminated by the light.¹⁰¹ Fixtures with a higher CRI produce light which allows for a more accurate color rendition. The low blue light content of these fixtures meant that many of the ecological, physiological, and health concerns associated with blue-rich LEDs would be minimized. In addition, the modular shielding would allow more precise direction of light - it would be possible to adjust shields on a given fixture in order to ensure the light would shine exactly where it was needed.¹⁰²

¹⁰¹ For a list of technical specifications of commonly available HPS bulbs, see Bulbs.com, *High Pressure Sodium High Intensity Discharge Light Bulbs*, <[https://www.bulbs.com/Under_60/High_Pressure_Sodium-High_Intensity_Discharge_\(HID\)-Light_Bulbs-Category/results.aspx?No=0](https://www.bulbs.com/Under_60/High_Pressure_Sodium-High_Intensity_Discharge_(HID)-Light_Bulbs-Category/results.aspx?No=0)> [accessed 24 September 2020]; Source for Lumican fixture CRI: my interview with CEO of Lumican.

¹⁰² Lumican, *Intro to Lumican* (No year given), p. 6.



Figure 19: Daytime image of Lumicana LED 2200 K fixture in Stanley, ID. 1 November, 2019. Photo: Jessica Heim.

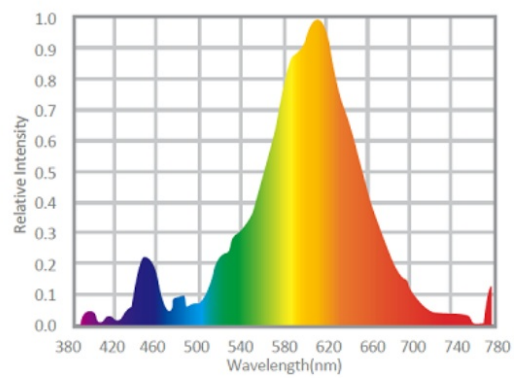


Figure 20: Spectral power distribution of Lumicana 2200 K LED, from 'Operation Dark Sky - The Problematic Blue: a Closer Look.' Image: Lumican



Figure 21: Lumicana, 60-80 Watts, LED, shielded, 2200 Kelvin, 8400-11,200 lumens, in Stanley, Idaho. (Different wattage and lumens were used for different intersections). Installed in 2019. Photo: Mayor of Stanley.

Though the mayor was intrigued by this possible lighting option, he wanted to ensure that the city made a sound decision before moving forward, noting, 'if we're gonna do this, we want to make sure we're doing it right, and we really analyze this.' As part of his research process, he mentioned that he had conversations with IDA staff, in which they discussed the minutiae of technical aspects of lighting in great detail. He said with a laugh, that as a result of his involvement with dark sky initiatives and Stanley's LED retrofits, 'I've learned a lot about - a lot more about lighting than I ever dreamed I would know!' It was evident that he was taking the town's retrofit seriously and that he sought to understand a great deal about all aspects of possible new lighting options.

During our interview, the mayor shared details about the process of choosing new lights and deciding to do another retrofit. 'We had a number of meetings with the city council,' he recalled, 'in which I laid out options and what my plan was to convert again. . . . And of course, the city council meetings are all open to the

public. So people could come and hear all of this.' Though he spent extensive time and energy researching streetlights, it was clear that the thoughts of city council members and the general public were of great importance in determining whether another retrofit would actually happen. 'It's got to meet all these different needs where people feel like, yeah, there's enough light, we feel safe. We can see how to drive our cars through the intersections,' the mayor noted, adding, 'we want people to be happy with the lights.' He also discussed the issue of cost and of having clear reasons for 'why we need to do it again - what do we really gain by doing it again?' He described his efforts to ensure that the new retrofit would resolve concerns pertaining to certain intersections being lit sufficiently, and he mentioned the modeling he had the Lumican engineers do to determine the proper wattage and fixture design for various intersections. 'I must have worked with Lumican for a year before I was happy,' he recalled. The process of deciding upon the particular streetlights to be used for this most recent retrofit was time consuming, and it was clear that a final decision was only reached after much discussion and deliberation involving the mayor, the city council, and feedback from local residents.

In the end, the city decided to use Lumican's fixtures in their retrofit, and they purchased 14 of them.¹⁰³ These fixtures were not available through distributors the local utility had existing relationships with, so the city would have to purchase them. In doing so, the city would be responsible for the costs of any future possible repairs or replacement of the streetlights, not the utility. However, the utility would still be the one doing the actual installation or other work on the fixtures. As the city had covered the cost of purchasing the fixtures, the utility would now pass on the savings from using more efficient LEDs into the city's utility bill. Stanley's mayor observed that purchasing the streetlights themselves was a definite expense and investment for the city but noted that 'they're [the utility] going to cut our power bill dramatically.' When asked how long it would take the city to recoup their costs, he said, 'within a few years, a couple of years or so, we'll probably break even.' However, he also remarked that reducing costs wasn't the driving factor behind the retrofit, noting that saving energy 'wasn't even

¹⁰³ Central Idaho Dark Sky Reserve, 'Annual Report,' Year 02, (October 2019), p. 6.

the primary reason we did it. It's a bonus, you know, to save the city money on each light and get our electric bill down.' So for this retrofit, while monetary issues were clearly an important consideration, the primary objective in doing this project was to implement LEDs which would be an illustration of 'dark sky friendly best practice.' By doing so, not only would the community reduce its light footprint on the surrounding wilderness areas and minimize some of the concerns commonly associated with LED lighting, but the installation would also serve educational purposes, as visitors would be able to see an example of what 'dark sky friendly' lighting could look like.

Community Responses to Stanley's 2019 Retrofit

As discussed earlier, my visit to Stanley occurred just prior to the complete retrofit of its streetlights in fall 2019, and all but one of my interviews with Stanley-area residents were conducted before the retrofit as well. Consequently, the majority of information I received on the community's response to the full retrofit came from my online questionnaire data, though I also received some feedback from the mayor regarding his thoughts on the completed project. This section will present and discuss some of the key themes found in residents' responses to the new lighting.

I received a total of 14 completed questionnaire responses. I likely would have had a larger number of responses had I been able to visit the community again - after the retrofit - and speak to residents in person at the library, restaurants, and other local establishments (an approach suggested by one of my interviewees, who believed this would be the best way to connect with a large number of the locals and interest them in completing my questionnaire). Unfortunately, I was unable to do this, so community awareness of my questionnaire was limited to what was possible with my 'snowball' distribution method. However, given this approach, coupled with the low population of the area, the number of responses received was still respectable.

Overall, the majority of the questionnaire respondents indicated that they were satisfied with the new streetlights in comparison to the fixtures which had been replaced. When asked how they liked 'the color and quality of the light emitted by these fixtures as compared to the previous fixtures,' 11 indicated they preferred the light produced by the new fixtures, one didn't have a preference either way, one said they weren't sure, and one preferred the light from the old fixtures (see fig. 22). Similarly, 12 shared that they believed the level of brightness of the new fixtures was 'about right,' one thought it was 'too dim' and one was 'not sure' (see fig. 23). Respondents also answered in similar proportions when asked about the size of the area illuminated by each of the new fixtures: 11 believed it was 'about right,' one thought there was 'not enough area illuminated,' and one was 'not sure' (see fig. 24). Based on responses to these questions, it appears that most

respondents found the brightness, area of illumination, and color and quality of light associated with the new fixtures to be to their liking.

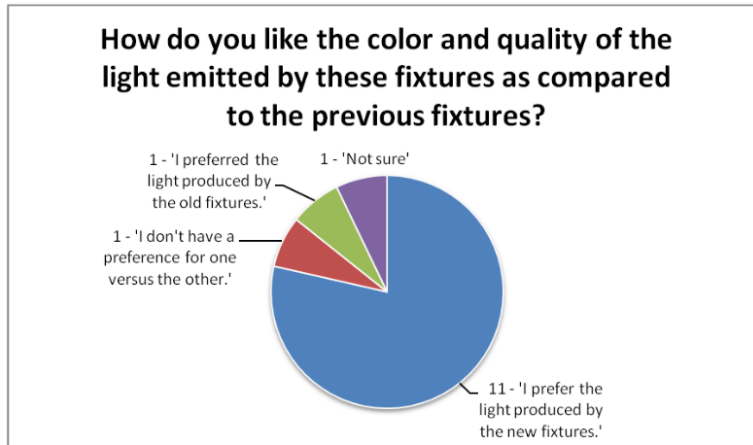


Figure 22: How Do You Like the Color and Quality of Light of the New Fixtures?

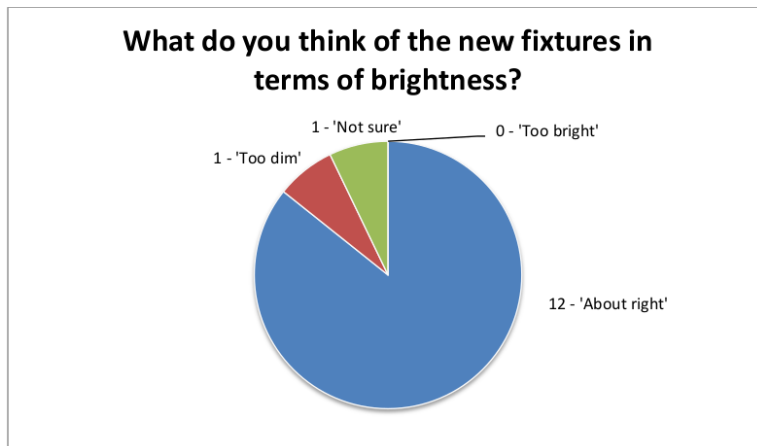


Figure 22: What Do You Think About the Brightness of the New Fixtures?

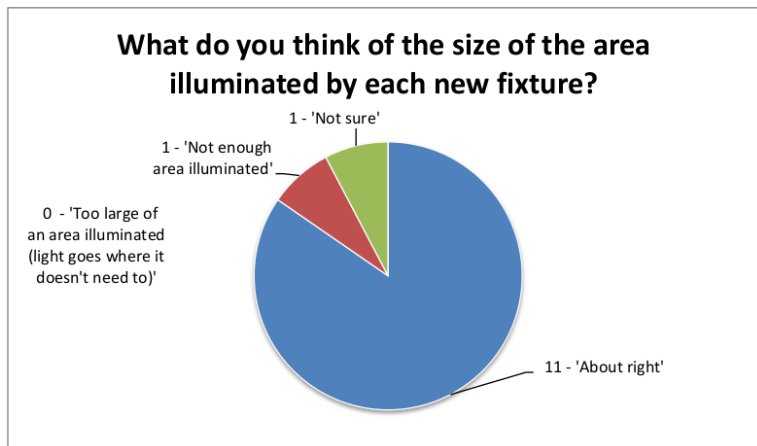


Figure 23: What Do You Think About the Size of the Area Illuminated by the New Fixtures?

However, some questions elicited a greater diversity of responses. For example, when asked whether they felt the new fixtures were brighter or dimmer than those they replaced, 5 thought 'the new fixtures are dimmer,' 4 believed 'they are about the same,' one thought 'they are brighter,' and 4 were unsure (see fig. 25). Asking whether the light from the new fixtures covered 'more or less area in comparison to the previous fixtures,' also resulted in mixed responses: one believed they 'illuminate a larger area,' 2 thought they 'illuminate a smaller area,' 8 perceived 'there was not much of a difference,' and 3 weren't sure (see fig. 26). Another question - focused on a comparison of the new fixtures to the old - also elicited somewhat varied responses; when asked whether the new fixtures were more or less comfortable to the eye (in terms of glare), 9 respondents found them to be 'more comfortable to the eye,' 3 thought they were 'about the same,' one found them to be 'less comfortable to the eye,' and one was 'not sure' (see fig. 27).

Do you feel that the new fixtures are brighter or dimmer than the fixtures they replaced?

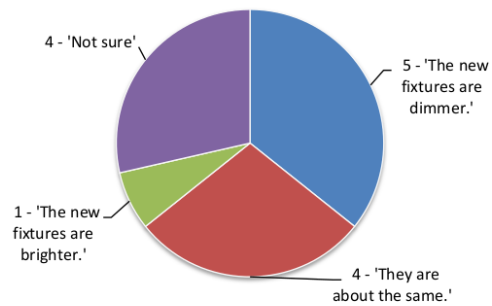


Figure 25: Are the New Fixtures Brighter or Dimmer Than the Old Fixtures?

Does it seem that the light produced by the new fixtures covers more or less area in comparison to the previous fixtures?

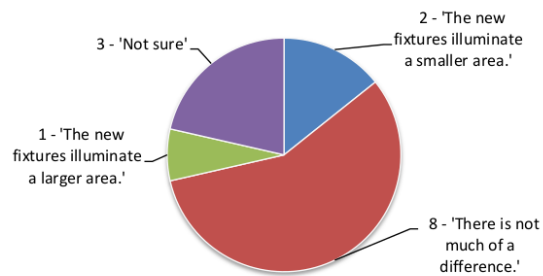


Figure 26: Does the New Fixtures' Light Cover More or Less Area Than That of the Old Fixtures?

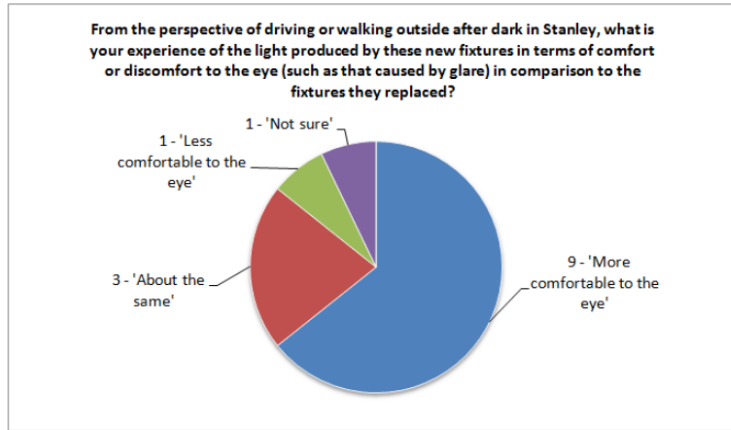


Figure 27: Is the Light From the New Fixtures More or Less Comfortable to the Eye Compared to the Old Fixtures?

In their inquiry into residents' perceptions of LED streetlights around Berlin, Besecke and Hänsch observed, 'Questions concerning the issue of lighting and darkness proved quite complex. Light possesses enormously diverse features and takes on a number of different forms within different spatial contexts. Moreover, there are considerable individual differences with regard to perceptions and evaluations of light and darkness.'¹⁰⁴ My findings certainly support this assertion, as respondents' perceptions of the light provided by the streetlights (in comparison to the previous ones) were quite varied. Some of the diversity of responses to these questions may be accounted for by the fact that there were multiple varieties of 'old' streetlights present prior to the retrofit, thus making a clear comparison of 'brighter versus dimmer' and illuminating a 'larger versus smaller' area of ground less straightforward to determine. Also, making such assessments can prove challenging when a side-by-side comparison is not available and people are making such evaluations using their recollection of lights which were no longer present. However, as the mayor recounted in his interview, based on the lumen output of the older LED varieties in comparison with Lumican's, the new fixtures - though having features considered more 'dark sky friendly' - actually emitted

¹⁰⁴ Besecke and Hänsch, 'Residents' Perceptions of Light and Darkness,' p. 243.

greater quantities of light and illuminated larger areas than any of the older LED fixtures. Lumican's fixtures, though, were better shielded, a feature which could result in the perception of less glare and might factor in residents' conceptions of 'brightness.' An additional added complexity to consider, beyond the amount of light reaching the eye, is how the human eye responds to different colors of light. The dark-adapted eye is very sensitive to blue wavelengths.¹⁰⁵ Thus when exposed to either of two sources of light, each emitting the same number of lumens, but one containing much blue light in its spectrum and one containing very little, the eye will perceive the blue-rich light as 'brighter.'¹⁰⁶ This presents an additional facet to consider when determining appropriate illumination levels for roadway lighting projects. Thus the combination of changes in lumens, shielding, and color temperature create a set of variables which different individuals may interpret in various ways.

The other questions about Stanley's streetlights in the questionnaire were focused on possible changes to visibility of the stars brought about by the new streetlights. When asked whether there was any difference in how well they could see the stars 'when looking from within or from very close to Stanley' as a result of the retrofit, a high percentage indicated that the change in lighting had increased the visibility of the stars: 10 reported, 'it is easier to see the stars,' 3 asserted, 'there isn't a noticeable difference,' and one said they weren't sure (see fig. 28). None indicated that it was 'more difficult to see the stars.' However, there were more mixed responses when asked whether the change in streetlights had impacted the view of the stars as seen from further outside the city: 6 indicated that there was 'less light coming from Stanley,' while 7 said there wasn't 'a noticeable difference,' and one was unsure (see fig. 29). However, like in the previous question, none indicated they saw 'more light coming from Stanley.' Based on these responses, it appears that despite the increased lumens utilized and the attempts to provide more coverage to the intersections in town, residents did not find that the retrofit diminished the darkness of the night sky. This offers support for the conclusion

¹⁰⁵ International Dark-Sky Association, *Fighting Light Pollution* (Mechanicsburg, PA: Stackpole Books, 2012), p. 93.

¹⁰⁶ International Dark-Sky Association, *Fighting Light Pollution* (Mechanicsburg, PA: Stackpole Books, 2012), p. 93.

that this retrofit did indeed successfully accomplish what it was intended to do: provide sufficient lighting on the ground while simultaneously reducing the amount of 'wasted' light contributing to glare and skyglow.

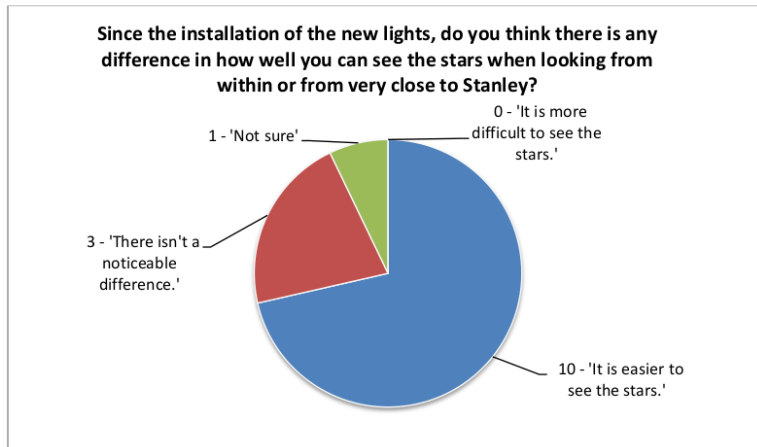


Figure 28: Have the New Fixtures Made it Easier or More Difficult to View Stars from Within Stanley?

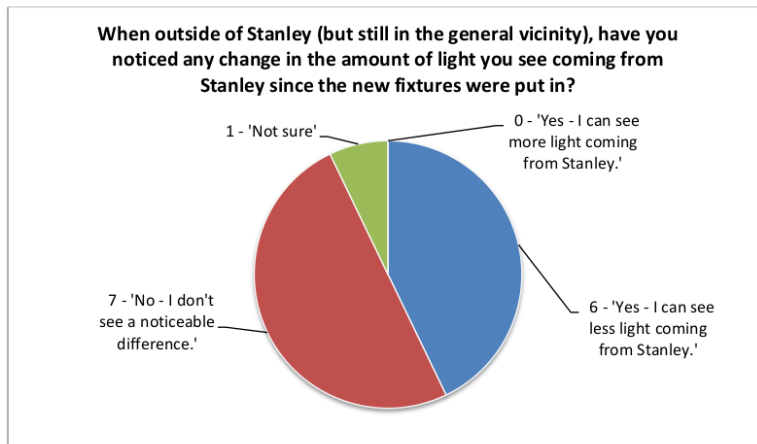


Figure 29: Have the New Fixtures Made it Easier or More Difficult to View Stars from Outside of Stanley?

After answering these multiple choice questions, questionnaire respondents were asked whether they had other 'feedback' they wished to share on their 'experiences with or thoughts about these new streetlights.' Half chose to share additional details. Five of the comments were supportive of the retrofit, one was neutral, and one was critical. One resident shared, 'Love the new fixtures and hope more cities follow suit.' Another thought the lights looked 'great' and believed that they 'set a great atmosphere for Stanley.' One respondent noted their approval of the reduced blue-content of the new lights, stating that this resulted in 'less glare and sky glow' and 'creates fewer deleterious impacts to wildlife.' Finally, one shared, 'I'm an amateur astronomer, and really appreciate the new lights.' For these individuals, it was clear that they were grateful for the retrofit and believed it was a positive change which enhanced their community. As one of my interviewees asserted, 'it's a dramatic improvement, and Stanley can be really proud of the light changes.' One respondent reported that some people in central Idaho 'initially resisted' the idea of 'protecting our dark skies' but reported hearing no complaints after Stanley's recent retrofit. 'Maybe I am just not talking to the right people,' they elaborated, 'but those I know are happy with the situation.' These remarks are consistent with both the ideals espoused in the city's Comprehensive Plan as well as with the kind of feedback I received from my interviewees about their perception of the larger community's response to the dark sky initiatives undertaken: as a whole, the majority of residents were supportive of lighting their community in a manner intended to maintain the darkness of the region's nighttime skies.

The one respondent who had a critical response to the retrofit elaborated on reasons for their dislike of the lights. 'We know the area really well, and we can stumble around in the low light conditions,' they remarked, 'However, 'tourists and our guests have a really hard time.' They reported, 'We hear complaints from most folks that are visiting Stanley.' They also appeared to believe that those who were interested in doing dark sky friendly lighting were in the minority, referring to such individuals as 'the few that rumble about light pollution.' Given the mention of tourist responses, I am unsure whether this individual's comments were referring exclusively to the new fixtures or to the earlier ones as well, as the main tourist season had already ended prior to the installation of the new fixtures. This

individual's assessment of the both the lights and the experiences of both residents and visitors in the area differed markedly from that expressed by all other survey respondents and interviewees. In order to get truly objective data on visitors' thoughts on Stanley's lights, it would be necessary to conduct a survey and record visitor comments in a systematic manner, an endeavor outside the scope and focus of this research. However, aside from the comments offered by this individual, all other evidence I examined indicated that visitors and residents who valued dark skies and found the street lighting in Stanley to be acceptable were commonplace.

After the retrofit had been completed, Stanley's mayor shared his experience of the new lighting, noting, 'I believe that the Lumican lights are far superior to the previous lights in every way - lumens, CCT, coverage, cost,' he opined. 'The Lumican lights provide more lumens per watt than the previous lights, so there is noticeably more light now and it is more directional by using the deflectors on the luminaries.' In his view, the retrofit resulted in enhanced quality of lighting overall. He did discuss his 'slight' continuing concern with one particular intersection - one which was especially wide, and consequently, was not well-lit with the previous lighting. Though he still didn't feel that the intersection was perfectly lit, he indicated that with the new fixtures, it was 'definitely' improved. He noted that he had received 'a complaint from one of the local business owners that he thinks the lights fail to provide adequate illumination of the intersections.' The mayor continued, 'I suppose this is subjective to a certain extent, and to me there is excellent illumination, but I do plan to request that Lumican evaluate this from the standpoint of lighting standards.' His experience was consistent with my other findings, in that disapproval of the streetlights was present in the community but was not widespread.

Respondents generally conveyed a definite opinion regarding their thoughts on the various aspects of lighting. With the exception of the perhaps more difficult questions of whether the new fixtures were brighter or dimmer than the ones they replaced and whether they illuminated a greater or smaller area, only one respondent indicated 'not sure' to other multiple choice questions in this section of the questionnaire. This individual also stated that they were unaware that the lights had been changed. So, among my respondents, there appeared to be a high rate of

awareness of the lighting changes and possible effects on the view of the night sky. This is quite different from what Besecke and Hänsch found: they noted a substantial portion of 'don't know' responses to questions regarding perception of new streetlights.¹⁰⁷ In particular, they observed the 'striking' result that 'don't know' was chosen 'much more often with regards to the impact of lighting on the stars, humans and nature - presumably because of a lack of knowledge.'¹⁰⁸ Though my sample size was significantly smaller and may or may not be completely representative of the entire population of the Stanley area, the marked lack of 'don't know' responses, coupled with the many additional comments given, lends support for the conclusion that Stanley residents are more aware of lighting changes and related issues than the urban and suburban populations surveyed by Besecke and Hänsch.

¹⁰⁷ Besecke and Hänsch, 'Residents' Perceptions of Light and Darkness,' p. 237.

¹⁰⁸ Besecke and Hänsch, 'Residents' Perceptions of Light and Darkness,' p. 237.

Community Experiences with Dark Skies & Dark Sky Initiatives

In the latter section of my questionnaire as well as in my interviews, I sought to ascertain respondents' and interviewees' thoughts and feelings about the regions' dark night skies, as well as their experiences with dark sky initiatives. Many elaborated in great breadth and depth as to why dark skies were important to them, how experiencing such skies made them feel, and why they believed it was essential to maintain the area's starry skies for current and future generations. The responses I received showed that nearly all respondents believed the area's starry night skies enhanced their quality of life and should be maintained. When asked whether the 'area's dark, starry night skies enrich your quality of life,' 11 replied, 'a great deal,' one said, 'somewhat,' one said they weren't sure, and one indicated, 'not at all' (see fig. 30). All but one shared additional thoughts on why this was the case, with most indicating how the starry skies made them feel. Peace, joy, and happiness were among the emotions elicited by being under such a sky and some described it as 'pleasant' or 'beautiful.' One remarked, 'Night sky and clean air are among the best parts of living here.' Though all but one response pointed to the idea of the night sky enhancing quality of life, one individual elaborated on this point explicitly, stating, 'The quality of life in Stanley is related to the quality of the surrounding natural environment. Starry night skies are an integral part of that environment, and an essential element of the wilderness experience that I enjoy.' For this person, the night sky was seen not simply as a nice addition to the mountains and forests of the region, but rather, was an 'integral' part of that environment. Another focused on the rarity of dark night skies in today's world, noting, 'There are few places in this country or the world' where such a sky can be seen, adding, 'I feel our beautiful night sky is a dramatic enhancement to our already spectacular home.' Thus for many, the region's dark skies were seen as a unique and valuable life-enhancing asset.

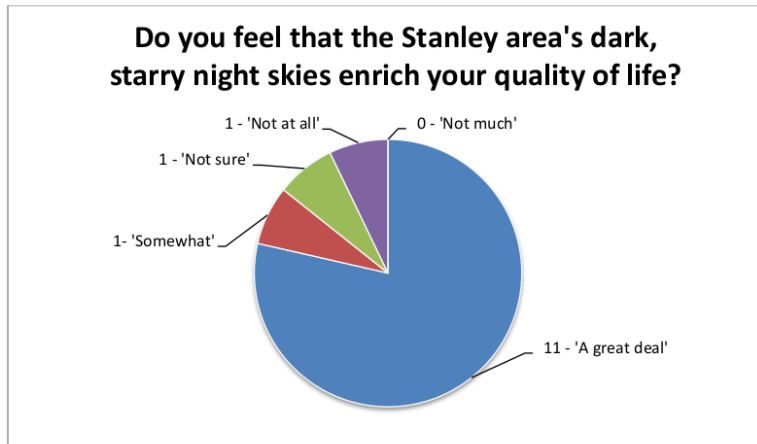


Figure 30: Do Stanley's Dark, Starry Night Skies Enrich Your Quality of Life?

The next question of the questionnaire asked, 'Is maintaining dark skies in Stanley and surrounding areas important to you?' Thirteen respondents indicated this was 'very important,' while one indicated it was 'not at all important' (see fig. 31). Of all the questions on the questionnaire, this one elicited the most unanimous response. When asked why they felt the way they did about maintaining the area's dark skies, 11 chose to elaborate further, and references to 'peace,' 'beauty,' and the 'economy' (the latter referring to astrotourism) were made. One indicated, 'I value the natural look;' another stated, 'It's essential to maintaining the quality of life that I enjoy.' For these individuals, preserving the region's dark skies was essential. When asked whether they had any 'particularly memorable experiences with the night sky,' 6 respondents shared additional information. One relayed being 'outside almost every night enjoying the stars,' while another noted that the night skies were a key reason for having moved to Stanley, recalling that they 'helped convince me that this was an incredibly special place and that I wanted to move here and stay forever... which I have managed to do so far!' It was clear that for many, Stanley's starry skies were understood as important and worthy of protection.

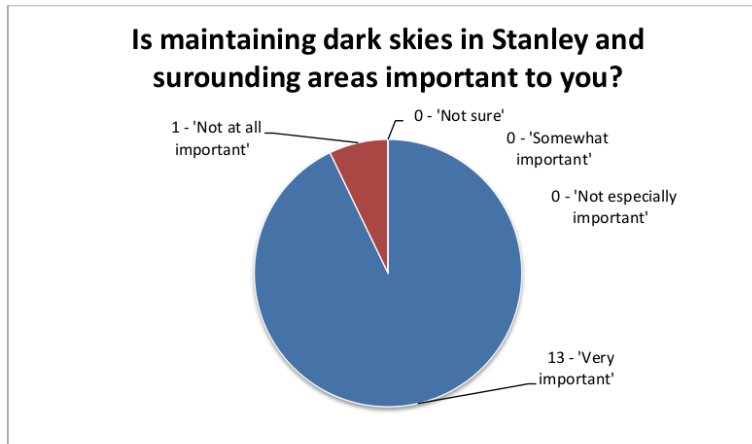


Figure 31: Is Maintaining Dark Skies in Stanley and Surrounding Areas Important to You?

Finally, respondents were given the opportunity to share further thoughts about outdoor lighting or dark skies. Six individuals chose to do so, with 4 making comments in support of dark sky friendly lighting or the reserve in general. One found 'even the slightest amount of light trespass' to be 'highly noticeable and objectionable' and asserted that it was 'important' for Stanley to 'achieve 100% compliance with all dark sky lighting standards.' Of the two remaining comments, one was against dark sky friendly lighting and one was an observation of another's view to this effect. 'I have a neighbor,' this latter respondent began, '- outside Stanley City Limits - who has added stadium lights to his property since the dark sky preserve was enacted. I think just to spite the dark sky proponents.' In a similar vein, the respondent who opposed the dark sky initiatives asserted, 'It's time to abandon this idea of these substandard fixtures and put bright lights in and restore safety and security to our town.' This respondent, who had indicated earlier that maintaining the area's dark skies was 'not at all important,' also expressed concern that dark sky friendly lighting would result in 'less tourism' in the area, as visitors would not want to come to a place which did not have 'safety and security,' aka 'bright' lighting in abundance. However, the remainder of the evidence I examined - interviewees' experiences, feedback from other individuals I spoke to while visiting the Stanley area, the plethora of media publicity advertising the

region's dark skies, etc. - pointed to an increase rather than decrease of visitation as a result of the dark sky initiatives.

Many interviewees shared details about the myriad ways in which dark skies were a part of their daily lives. One, a school teacher at the local elementary/middle school (with a total enrollment of 10 students) mentioned that they talk about dark skies in her classes at school, discussing 'how lucky we are' to have such beautiful skies in Stanley. She noted, 'And the kids, I think, really appreciate the dark skies, too, which is cool.' She and her husband live on an unplowed Forest Service road, so during the winter, she skis two miles to get to her car (parked in a pullout on a plowed road), drives the remaining distance to school, and then repeats this journey in reverse at the end of the day. 'If it's below 30 below, [Fahrenheit] we cancel school. So that helps,' she noted. This experience made her feel more connected to the stars, as it is typically dark during her commute. 'I just feel like they're my friends,' she said of the stars, 'keeping watch over us, . . . make me realize that, there's so much more out there.' She tried to explain her feelings about the stars, but found it challenging to do so: 'I think they just make me feel - I don't know. I don't - I don't think I can put that into words. But they are very important to me.' This sense of starry night skies being a source of inspiration and an important part of life in Stanley was a common theme among interviewees.

Several interviewees detailed their experiences with local dark sky initiatives and shared their thoughts on why they believed participating in such efforts was definitely worth their time and energy. One shared his 'realization' that 'dark skies are something that you need to consciously protect. Or they can disappear.' This awareness has led to him and his wife getting involved with efforts to maintain the region's night skies. He noted that many people in the area tend to 'take for granted' the area's dark skies, not seeming to realize that, absent efforts to maintain it, 'little by little, light pollution creeps in.' He mentioned that dark skies are 'a pretty important part of the natural world,' noting, for instance their role in 'animal and bird migration,' and his wife discussed the significance of dark skies in 'the well-being of humans.' They felt it was important to do their part to help others to

understand the value of maintaining the area's night skies and to realize that the actions of individuals do matter in ensuring the preservation of this asset.

One subject that repeatedly came up with my interviewees was the idea of mandatory versus voluntary compliance with 'dark sky friendly' lighting. The subject of regulatory frameworks is widely discussed in the dark sky advocacy community. Schulte-Römer *et al* devote substantial space to discussion of this topic in their research.¹⁰⁹ The 'experts' they interviewed tended to argue that a combination of regulatory guidelines accompanied by hard law was necessary to successfully mitigate light pollution, particularly in large urban communities. Yet even with the existence of lighting ordinances and other laws, those interviewees noted the difficulty of enforcing such rules. The larger communities of the reserve all have ordinances dictating specifics of allowed lighting, as do the counties. The community of Stanley, however, has taken a different approach and does not have such an ordinance. A point mentioned by the IDA is that, when engaging in dark sky activism, 'it is essential to grasp the needs - and the fears - of the community.'¹¹⁰ The individuals I interviewed appeared well-aware of this and were keen to approach others in a manner which would not alienate them. One of my interviewees noted the 'independent mindset' common to people in this rural region. Another observed: 'typical people in Central Idaho, they tend to rebel against ordinances.' Thus the approach in this community has been to work with individuals on voluntarily changing their lights, rather than legally requiring them to do so. The mayor described the success of this approach, noting, 'if you look around town, almost all the lights have been converted voluntarily.' He expressed hesitancy about the idea of 'scaring' people with an ordinance, 'Because the mere fact of passing one implies that you're going to use the city's police power, which you can. I mean, that gives you the legal right to do it. But if you can get people to comply without that, so much the better.' Regarding existing non-dark sky friendly lighting, he explained, 'we just contact the people and say, you know, this is what

¹⁰⁹ Nona Schulte-Römer, Etta Dannemann, and Josiane Meier, *Light Pollution -a Global Discussion*, (Leipzig, Germany: UFZ Helmholtz Centre for Environmental Research, 2018), pp. 123-168.

¹¹⁰ International Dark-Sky Association, *Fighting Light Pollution* (Mechanicsburg, PA: Stackpole Books, 2012), p. 104.

we're trying to do around here and you can save a lot of money and the technology is there and they usually want to comply with that.' He noted that once people realized that creating the reserve wasn't going to prevent them from managing their land or otherwise impinge on their ability to engage in activities that were important to them, they generally were more accepting about the idea.

Though one expressed a preference for having some sort of lighting ordinance, the consensus among my interviewees was generally that the strictly voluntary approach seemed to be the best way to convince Stanley-area residents to alter their lighting. One asserted definitively, 'It would NOT have worked' if the city had attempted to mandate that locals change the lighting on their properties. Though multiple interviewees noted the presence of a few in the community who were still opposed to non-glaring, downward-cast lighting, all were of the opinion that such individuals were not typical in the Stanley area. As one remarked, 'the majority of people here, I think, really do respect and really do enjoy their night sky.'

Though Meier was able to group the dark sky actors in her research into categories, each with discerning characteristics, I found that my interviewees did not easily fit into distinct boxes, as the reasons for supporting dark sky conservation tended to be manifold for a given interviewee. Additionally, I found that actors which superficially could be assigned to a category, such as 'politician,' did not necessarily share the same core reasons for supporting dark skies as did Meier's research subjects. For example, Meier found that politicians tended to be primarily interested in dark sky place designations 'as a means of increasing publicity' for their area and to 'strengthen' their 'town or region's development, particularly in economic terms.'¹¹¹ Though Stanley's mayor certainly was aware of these potential benefits of the dark sky reserve designation and was supportive of them, issues such as the importance of dark skies for the region's ecological health and the role dark skies played in the 'quality of life' of the area's residents seemed to be at the forefront of his mind. Similarly, in discussing his company's

¹¹¹ Josiane Meier, 'Designating Dark Sky Areas: Actors and Interests', in *Urban Lighting, Light Pollution and Society*, ed. by Josiane, Meier, Ute Hasenöhrl, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), p. 189.

development of 'dark sky friendly' lighting, Lumican's CEO expressed many ideas different from what might be expected from a 'business person.' He referred to his company's lighting as not just 'dark sky' lighting, but 'responsible' lighting. 'Responsible lighting,' he explained, 'is not blasting your neighbor or causing a car accident or a pedestrian unable to see when he's walking a certain area.' He believed strongly in the importance of non-glaring, shielded lighting for the sake of being a good neighbor and a conscientious member of the community, and he was particularly passionate when he spoke about minimizing ALAN's impact on wildlife. 'Of course, I care about dark sky,' he said, 'And I care about people seeing stars, but not near as much as I care about all the ecosystems that we can and cannot see that are affected by any - any human being that decides that he just wants to throw up a light.' In sum, I found my interviewees generally tended to be quite knowledgeable about a wide variety of rationales for maintaining dark skies, and the reasons they were most enthusiastic about were often different from those I had expected.

Chapter 5: Conclusion

The aim of this research was to examine a 'dark sky friendly' LED streetlight retrofit in the small rural town of Stanley, Idaho, with the goal of better understanding the process which enabled this endeavor to come to fruition, attributes of the lighting chosen, and responses of community members to this lighting change and dark sky initiatives more generally. In particular, it sought to gain a deeper understanding of both the thoughts and actions of key actors involved with advocating for and implementing such 'dark sky friendly' lighting changes in this region. A combination of semi-structured interviews and an online questionnaire were used to gather information about residents' thoughts and experiences with the new streetlights and dark sky initiatives. Additionally, relevant primary sources were utilized to learn additional information about these endeavors, and findings were examined in the context of relevant secondary literature.

While my 'snowball' sampling approach for identifying interviewees and similar strategy for distributing my questionnaire (as well as small sample sizes) did not result in data suitable for statistical analysis - unlike Besecke and Hänsch's much larger survey of residents living near Berlin - it allowed for an in-depth examination of the views and experiences of individuals participating in this research.¹¹² As Blair reflected regarding her similar research approach and small sample size for her work on Sark, 'the advantage of small samples is that we can focus on individual stories rather than aiming for some mass opinion which might not exist anyway'.¹¹³ As my objectives were primarily to get a glimpse into the experiences, lives and stories of those most engaged with dark sky advocacy in Stanley and to understand the details of the streetlight retrofit itself, a randomized sampling approach was not necessary. Additionally, the use of interviews to obtain the bulk of my data was well-suited for accomplishing my aims. As

¹¹² Anja Besecke and Robert Hänsch, 'Residents' Perceptions of Light and Darkness' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane Meier, Ute Hasenöhl, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), pp. 224-248.

¹¹³ Ada Blair, *Sark in the Dark: Wellbeing and Community on the Dark Sky Island of Sark* (Ceredigion, Wales: Sophia Centre Press, 2016), p. 94.

Hennick *et al* observe, interviews allow the researcher to 'gain in-depth information' and to 'identify individual perceptions, beliefs, feelings and experiences' - tasks central to my research.¹¹⁴

The streetlights used in Stanley's recent retrofit were selected with the chief goals of providing well-lit intersections while minimizing wasted light. These particular fixtures were chosen in large part because of their low CCT (and low blue light content) and design allowing for light to be directed more precisely - both features intended to reduce glare and eyestrain, as well as impact on the nocturnal environment. By installing such fixtures, Stanley sought to reduce its light pollution and be a model of dark sky friendly lighting. This idea of creating a model example is also found in Schulte-Römer *et al's* findings. They note that '95%' of their global expert survey respondents 'strongly or very strongly recommended the promotion of best practice,' as a means to reduce light pollution.¹¹⁵ This was precisely what dark sky advocates in Stanley and the CIDSr were aiming to accomplish. As Stanley's mayor observed, 'if we can make it work here within this reserve, we can set a standard example for other people in other parts of the country to follow.'

Based on responses to questions about Stanley's new streetlights in my questionnaire and my interviewees' recollections of interactions with other community members (all discussed in detail in my findings), it appears that overall, the streetlight retrofit was well-received by the majority of Stanley-area residents. Both Stanley's recent LED streetlight retrofit and success at encouraging locals to adopt dark sky friendly lighting were a result of a long history of sustained efforts of many individuals passionate about dark skies. In order for dark sky initiatives - such as the creation of the CIDSr and the recent streetlight retrofit- to be successful in the Stanley area, there were several factors which needed to be in place. There was the necessity of general community approval of the city's plans, as well as widespread interest in dark skies accompanied by the

¹¹⁴ Monique Hennick, Inge Hutter, and Ajay Bailey, *Qualitative Research Methods* (London: Sage Publications, 2011), p. 53.

¹¹⁵ Nona Schulte-Römer, Etta Dannemann, and Josiane Meier, *Light Pollution -a Global Discussion*, (Leipzig, Germany: UFZ Helmholtz Centre for Environmental Research, 2018), p. 201.

belief that dark skies were a valuable asset to the community. The prerequisite of community-wide interest needed for dark sky initiatives to move forward has been noted by many others. For instance, in her study of Sark's journey to becoming a Dark Sky Island, Blair observed that, though it was essential to have a dedicated group of highly involved advocates, 'the commitment of the whole island would be required' for Sark to be successful in a quest to become a dark sky community.¹¹⁶ Without a broad base of support, success was unlikely. Similarly, the IDA notes that the establishment of dark sky places 'cannot be accomplished without the creation of a pervasive dark sky culture.'¹¹⁷ In other words, people need to care about the night sky if they are to support efforts to maintain it. A necessary precursor for such a 'dark sky culture' however, is an awareness of dark skies and the existence and consequences of light pollution. In the responses to their 'global expert survey' on lighting and light pollution issues, Schulte-Römer et al found that 'A lack of awareness of the problem, especially among light users, is the most frequently mentioned obstacle' to reducing light pollution.¹¹⁸ Likewise, several of my interviewees noted they had found this to be the case as well, observing that many who had lived their whole lives in the area hadn't realized it was all that unusual to be able to see such starry skies, nor had they considered the collective impact of their individual lighting choices. However, as a result of the ongoing efforts of dark sky proponents, over time, more residents became sympathetic to the cause and many voluntarily changed the lights around their homes and businesses. As one of my interviewees - who has lived in the Stanley area for more than 40 years - noted, a marked change had transpired over the years: 'ten years ago, you'd look down the valley from Galena Summit and you didn't see a dark valley,' but now, 'Stanley is not glowing in the dark as it used to be. . . . that's a real progression that has occurred, and I'm proud to be a part of it.'

In a similar vein, analogous to Schulte-Römer *et al's* findings that those involved with light pollution issues believe that 'personal education [is] more

¹¹⁶ Blair, *Sark in the Dark*, pp. 21-22.

¹¹⁷ International Dark-Sky Association, *Fighting Light Pollution* (Mechanicsburg, PA: Stackpole Books, 2012), p. 149.

¹¹⁸ Schulte-Römer, Dannemann, and Meier, *Light Pollution: A Global Discussion*, p. 187.

promising than transforming institutions or establishing lighting standards and legal frameworks,' all of my 'dark sky advocate' interviewees expressed the importance of communication and education in relation to dark sky issues.¹¹⁹ Such community interaction appeared to be the central keystone to success in the widespread implementation of dark sky friendly lighting. There needed to be opportunities for supporters of dark sky initiatives to share their ideas with the community in friendly, non-confrontational ways and for them to truly listen to any concerns others may have had, with the intention of devising win-win solutions. This was a long-term and ongoing process, and all of these interviewees demonstrated their willingness to be persistent, patient, and to continue to share their love of the night sky and the benefits of non-glaring lighting with others for the long-haul.

The efforts of dark sky advocates to meet people where they were at and to seek common ground appeared to be essential aspects of creating a wide base of support for the streetlight retrofit and dark sky lighting more generally in the Stanley area. As Meier found, 'the support of a multitude of stakeholders' is necessary for dark sky initiatives to succeed, and the motivations driving potential interest in dark skies preservation varies among actors.¹²⁰ For example, one of my interviewees noted that a perspective which was encouraging some doubters to reconsider uninhibited outdoor lighting was the idea of 'light trespass,' or 'stray lighting going where it is not wanted' (such as onto others' property).¹²¹ He indicated that such residents - who otherwise did not take kindly to the idea of anyone dictating what kind of lights they should use - could relate to the concept of 'trespassing light' infringing upon property rights and were more amenable to discussion of lighting changes in this context. According to Stanley's mayor, some business owners were intrigued by the idea of dark skies drawing in more tourists. Those who found

¹¹⁹ Schulte-Römer, Dannemann, and Meier, *Light Pollution: A Global Discussion*, p. 201.

¹²⁰ Josiane Meier, 'Designating Dark Sky Areas: Actors and Interests', in *Urban Lighting, Light Pollution and Society*, ed. by Josiane, Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), p. 193.

¹²¹ Martin Morgan-Taylor, 'Regulating Light Pollution in Europe: Legal Challenges and Ways Forward,' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane, Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), p. 161.

dark skies to be an important component of their 'quality of life' in Stanley were generally supportive of efforts to keep the skies dark. These findings are consistent with Meier's observation that, 'What carries the initiatives is that all identified actors see pre-existing interests of theirs matched by potential benefits resulting from the designation.'¹²² This concept was mentioned explicitly by Stanley-area forest ranger Kirk Flannigan, who noted, 'The Dark Sky Reserve designation is a perfect fit for the Sawtooth NRA, as it supports our enabling legislation, which in part mandates the Forest Service to protect and preserve the natural and scenic qualities of the area.'¹²³ For dark sky initiatives to gain broad support, it is essential that advocates are aware of the interests and concerns of various groups in the community and find ways that dark skies preservation might benefit different people in different ways. 'Though their interests are diverse,' Meier observes of the many actors participating in dark skies preservation, 'they do not infringe upon each other: they align, overlap or complement each other.'¹²⁴ Thus, even if not everyone in a community agrees that preserving dark skies is important for the sake of maintaining a starry nighttime view, there may be other compelling reasons why they might want to embrace dark sky friendly lighting.

Though there were numerous explanations voiced as to why it was important to maintain the area's starry night skies, 'quality of life' was a motivation brought up repeatedly. This concept was typically seen to be quite broad and all-encompassing, including things as diverse as: being able to view the stars and ponder the immensity of the universe, having outdoor lighting which does not create blinding glare, and maintaining a healthy nocturnal environment for the benefit of the non-human inhabitants of the surrounding wild lands. Regarding the question of why he invests his time and energy on this issue, the mayor of Stanley's response was typical of those I spoke with: 'Better quality of life. And that's what it all boils down to, to me, is how do I do that?' He noted that the dark sky was one

¹²² Meier, 'Designating Dark Sky Areas: Actors and Interests,' p. 191.

¹²³ Central Idaho Dark Sky Reserve, 'Central Idaho Earns Designation as the Nation's First Dark Sky Reserve,' Press Release, (18 December 2017), < <https://www.darksky.org/wp-content/uploads/2017/12/CIDSR-Press-Release.pdf> > [accessed 16 September 2020].

¹²⁴ Meier, 'Designating Dark Sky Areas: Actors and Interests,' p. 191.

'really important' aspect of quality of life in Stanley and observed the increasing rarity of dark skies elsewhere, adding, 'And so it's worth investing my time and effort in that.' Another interviewee remarked, referring to the area's beautiful land and nighttime skies, 'I always tell people that when I moved to Stanley, I died and went to heaven. Why would I ever leave?' Evidently, for many Stanley residents, dark skies do indeed promote well-being. Thus, this research provides additional support for Blair's assertion of the value of dark skies in this regard.¹²⁵

In Stanley, the starry night sky isn't an abstract theoretical concept: it is a tangible part of the environment, which can be experienced as simply as walking outside and looking up. The continued ability to have personal experiences with and develop a connection to the night sky may be one of the most essential components of interest in dark sky protection. Bogard elaborates, 'The fact that people see something with their own eyes has incredible power - you can see photographs of Saturn a thousand times and be somewhat impressed, but see it for yourself and you don't soon forget.'¹²⁶ In earlier research, I found much support for this assertion and concluded, 'it is the personal, firsthand experience with the night sky, particularly as a child, which has the deepest and most transformational effect upon a person and creates a sense of connection to the cosmos.'¹²⁷ Absent the ability to connect with the night sky in this way, perhaps, as Nordgren argues, we lose something more than simply a pretty view: 'we lose the ability to see that great sign in the sky that we are part of a larger Universe. . . . we lose our place in the Universe.'¹²⁸ Though loss of a starry night sky may be the current observed reality in many places, in Stanley, thousands of stars are still visible to all who look up at night.

¹²⁵ Blair, *Sark in the Dark*, p. 147.

¹²⁶ Paul Bogard, *The End of Night: Search for Natural Darkness in an Age of Artificial Light* (London: Little Brown and Company, 2013), p. 31. (double check wording and punctuation)

¹²⁷ Jessica Heim, 'The Night sky in the Lives of Amateur and Professional Astronomers,' *SPICA*, 5(2), Sophia Centre Press, (2018), p. 52.

¹²⁸ Tyler Nordgren, *Stars Above, Earth Below: A Guide to Astronomy in the National Parks* (Chichester, UK: Praxis, 2010), p. 428.

In conclusion, as Terrell Gallaway argues, 'The night sky is a superlatively wondrous and deeply threatened natural asset. Its importance is vast and its role in nature and culture is multifaceted and sweeping.'¹²⁹ Dark night skies are important for the health and well-being for people and wildlife alike. Though light pollution is becoming a more pervasive concern and in many places, is steadily increasing with each passing year, the findings of this research and that of others show that, however challenging it may be, it is possible for communities to create lighting changes which address people's needs while also minimizing glare and wasted light. By advancing interdisciplinary research on lighting and dark sky issues, additional knowledge can be gained on the effects of ALAN, along with insight into possible ways to address emerging challenges. Such research, combined with the sharing of findings with scholars across disciplinary boundaries and the with the general public as well, is essential to both raise awareness of light pollution and to aid communities in devising solutions which meet their needs. There ought not be a 'one-sized fits all' approach; indeed, Schulte-Römer *et al* note the importance of 'individualizing the solutions.'¹³⁰ Therein lies the value of in-depth case studies of communities engaged with dark sky advocacy. The greater variety of places (urban, rural, small, large, etc.) studied in this manner, the easier it will be to both come to a greater understanding of the key factors at play in different areas and for individuals to apply relevant solutions to their own communities. Additionally, increased access to dark skies and the opportunity for more people to directly experience them are essential if the trend towards ever-increasing light pollution is to be slowed or reversed. As Bogard observes, if people are to care about and seek to maintain dark sky locales, 'they will have to be dark places we actually know and visit, love and respect.'¹³¹ As my dissertation shows, by increasing research, education, and experiences focused on dark skies, lasting changes in the way we light our communities and relate to the night become possible.

¹²⁹ Terrell Gallaway, 'The Value of the Night Sky,' in *Urban Lighting, Light Pollution and Society*, ed. by Josiane Meier, Ute Hasenöhr, Katharina Krause and Merle Pottharst (New York, NY: Routledge, 2015), p.267.

¹³⁰ Schulte-Römer, Dannemann, and Meier, *Light Pollution: A Global Discussion*, p. 202.

¹³¹ Bogard, *The End of Night*, p. 261.

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Appendix: Dissertation Proposal



Faculty of Humanities

MA Dissertation Approval Form

Student Name	Jessica Lynn Heim
Degree Scheme	MA CULTURAL ASTRONOMY AND ASTROLOGY
Module code	AHAN 7025
Start date (This will be after you have completed your 6 th module)	1 October 2017
Completion Date (The date when your MA registration ends)	30 September 2019

I have completed Part 1 of my degree.

*Please delete as appropriate.

Please read the 'Guide to filling out your proposal' at the end of this form.

Title of Dissertation:

Dark Sky Community Activism: How Communities Respond to Light Pollution and Advocate Change.

Aims:

The purpose of this research is to gain insight into the process by which communities successfully advocate for lighting policies that reduce light pollution. It will examine components of this process ranging from the attributes of dark sky friendly fixtures, to the political process and community engagement necessary to enact change, as well as to the actual lighting plans and policies themselves. It aims to identify steps which communities can take which will enable them to most efficiently and effectively create and adopt lighting plans which significantly reduce light pollution.

In the past few years, many communities have begun replacing their existing exterior lights with LED fixtures. LEDs are more energy efficient than older kinds of outdoor lighting, and the cost of LEDs has decreased substantially in recent years, thus making the switch to LED streetlights an increasingly affordable option for municipalities. Many of the new LED fixtures emit much more light in the bluer part of the spectrum, resulting in an increase in glare and light pollution, yet dark sky friendly LEDs and fixtures are available. This research will place particular emphasis on communities which have implemented LED conversions which reduce light pollution and better preserve dark skies.

Academic Rational:

Light Pollution is a problem which is not new, but is growing in scope, both in terms of the area of earth which is affected and in terms of the magnitude of the pollution. Light pollution, "excessive and inappropriate artificial light at night," has many consequences.¹³² It brightens the sky, making the Milky Way and other celestial objects invisible. This is not only problematic for professional and amateur astronomers; it also prevents the ordinary person from being able to see much of what is outside earth's atmosphere and from having a personal, firsthand experience of and connection to the larger universe. In addition, light pollution affects the physiology and behavior of many species of wildlife and can have adverse consequences for these creatures.

The use of LEDs in exterior lighting applications has greatly hastened the spread and increased the extent of these issues. Many municipalities are converting their streetlights to LEDs, with the goal of saving electricity and money, and businesses are following suit as well in the lighting of their parking lots. However, many of the LEDs used produce whiter light and emit much more light in the bluer part of the spectrum, which is associated with concerns ranging from negative consequences for the health of humans and wildlife, to greatly increased skyglow and light pollution. Fabio Falchi *et al* have estimated that the widespread adoption

¹³² International Dark-Sky Association, *Fighting Light Pollution* (Mechanicsburg, PA: Stackpole Books, 2012), p. vii.

of such 4,000 K CCT LEDs could increase skyglow levels between two and three times their current levels.¹³³

Another reason why adoption of LEDs can increase light pollution lies in their efficiency. Christopher Kyba *et al* have found that light pollution levels have been increasing by about 2% a year worldwide between 2012 and 2016 (a timeframe within which LEDs have begun to be more widely used).¹³⁴ The savings from LEDs' efficiency is often not fully utilized, with some of the savings often being allocated towards additional lighting. Thus, paradoxically, the availability of relatively low cost and efficient LEDs is resulting in an increase in outdoor lighting, particularly in parts of the world which formerly emitted little light pollution.

Though LEDs have the potential to revolutionize humans' ability to decrease light pollution (dimmers, motion sensors, and timers can be put to better use than with older lighting technology, directionality of light can be more precisely aimed, and spectral emissions can be altered so as to emit less light in undesirable parts of the spectrum) without intentional use of such features, widespread use of LEDs will simply lead to increasing levels of light pollution worldwide.

Research is being done on the negative effects of light pollution, in areas as diverse as wildlife biology, human health and well-being, and the value of the accessibility of dark skies as a part of cultural heritage. However, public awareness of the harm caused by this pollution is quite minimal, in comparison to issues such as climate change or other kinds of pollution. Lack of awareness of both the problems caused by much of the new LED lighting as well as the fact that there are cost effective alternatives, in addition to lack of knowledge on how to effectively implement such changes means that much of the time, LED installations worsen a community's level of light pollution.

By delving into the stories of those involved in dark sky activism and studying the details of their efforts to preserve the night sky, this research aims to illustrate potential paths other communities may take to regain or preserve their own dark skies.

To which module/s of the MA does your topic relate?

Researching Contemporary Cosmologies
Heavenly Discourses

¹³³ Fabio Falchi, *et al* 'The new world atlas of artificial night sky brightness,' *Science Advances*, 2 (6), American Association for the Advancement of Science, (2016).

¹³⁴ Christopher C. Kyba *et al*, 'Artificially Lit Surface of Earth at Night Increasing in Radiance and Extent,' *Science Advances*, 3 (11), (2017) e170158.

What papers have you completed in the MA which are relevant to this dissertation topic? List the module and the title of the paper/s.

Researching Contemporary Cosmologies - 'The Night Sky in the Lives of Amateur and Professional Astronomers.'

Heavenly Discourses - 'Sky Journal on the Relationship between Sky and Water in Minnesota'

Methodology:

1. I will review the literature on dark skies and light pollution, from perspectives including those of science, sociology and anthropology. In addition, I will review the municipal lighting plans in question, information posted about these projects on the IDA and IDA chapter websites, and information provided by individuals involved. Also, I will draw on academic studies such the paper by John Barentine *et al* about skyglow changes as a result of LED conversions in Tuscon, AZ, which was published in the *Journal of Quantitative Spectroscopy and Radiative Transfer*.

2. I will then conduct field work (qualitative research), identifying towns and cities which have made substantial progress in implementing dark sky friendly lighting, connecting with and interviewing the relevant people involved in these projects (community activists, leaders of IDA chapters, individuals on planning commissions, etc.), and learn about the process of implementing dark sky friendly lighting.

Short Introductory Bibliography: 1. Secondary Sources (Scholarly Works)

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The "Dark and quiet skies" proposal as an initiative under the auspices of the

Committee on the Peaceful Uses of Outer Space for protecting the environmental observing conditions for large astronomical observatories and world citizens, submitted by the International Astronomical Union (IAU), Committee on the Peaceful Uses of Outer Space Sixtieth Session, 7-16 June 2017, (Vienna, Austria: Committee on the Peaceful Uses of Outer Space, 2017).

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Short Introductory Bibliography: 2 Primary Sources (Original Works/ Documents)

Materials provided by community activists (such as brochures and other materials they have designed to inform officials and the general public about light pollution and the benefits of dark sky friendly streetlight plans)

Municipal lighting plans and ordinances

Time Schedule:

An outline of a likely timetable to completion.

Design interview questions. Complete by September 1, 2018.

Complete University's Ethics Form. Complete by September 15, 2018.

Determine who would be good to interview, reach out to these individuals and ask them if they would be willing to be interviewed. Finalize list of main interviewees by September 15, 2018.

Conduct interviews, beginning in October 2018. Complete all interviews by November 1, 2018.

Continue communicating and reaching out to those involved in the implementation of dark sky friendly lighting in communities where substantial changes have been made.

Begin writing: November 1, 2018

Analyze interview transcripts and determine key themes to mention in my dissertation. Complete by December 1, 2018.

Finish reading all articles and books listed in the bibliography (plus more): December 1, 2018

Synthesize information from secondary sources with thoughts of interviewees and determine how to organize this into dissertation. Complete by January 1, 2018.

Submit: March 1, 2019
Proposed Supervisor: Nick Campion

Please indicate whether ethical approval for project is needed – YES
(This will only be relevant if you are undertaking qualitative research)

Please indicate whether sufficient resources are available for the project –
YES

The above topic, proposal, and supervisor have been agreed:

Signed : Nick Campion 23 Aug 2018

Programme Coordinator

Date:.....

**Please return this draft form to your dissertation supervisor. When
completed then send Dr Bernadette Brady email:
b.brady@uwtsd.ac.uk**