

The Impact of Light Pollution on Ecosystems and their Services: Understanding and Communicating the Value of Dark Skies

By

Sharolyn Jo Anderson

A thesis submitted for the degree of Doctor of Philosophy
of
The Australian National University

March 2024

© Copyright by Sharolyn Jo Anderson 2024
All Rights Reserved

Declaration

I declare that the work presented in this thesis contains my original work undertaken in the Crawford School of Public Policy at the Australian National University. Neither this thesis nor part of this thesis has been submitted for any other academic degree. A paper has been submitted to be published from Chapter 3. This paper was produced jointly with Drs. Kubiszewski and Sutton, thesis supervisor and frequent collaborator. I was responsible for analysing the data, and 90 percent of the writeup, while Dr. Sutton took the responsibility of refining the analysis and both Drs Kubiszewski and Sutton edited the final writeup. Chapter 5 is a refinement of an earlier version of the chapter that was prepared as a manuscript for publication with a member of my supervisory panel, Dr. Delene Weber. I was responsible for 90 percent of the ideas and write-up, and Dr. Sutton contributed to some of the initial ideas and write-up. In addition, Drs Weber, Sutton, and Pitman helped with the distribution of the survey instruments. Dr Pitman helped with refining the ecological literacy questions and final edits on writeup. Excluding the exceptions above, the ideas and research detailed in this thesis are solely mine, except otherwise indicated. All assistance I received in preparing this thesis and its sources have been acknowledged.

Sharolyn Anderson

27 March 2024

Acknowledgments

I want to respectfully acknowledge that my work took place on the ancient Aboriginal Country of the Ngunnawal people. I pay my respects to their Elders past, present and emerging.

I am thankful for my supervisors Ida Kubiszewski, Robert Costanza, and Delene Weber for their guidance, support, encouragement, and insights, which contributed to the success of this research. I am also very grateful for the support I received from Sheryn Pitman and Mark Earl both of whom welcomed me into their community of Carrickalinga. My research would not have been possible without the willingness of the citizens, students, and scholars to partake in the surveys I organised, so I wish to convey my appreciation to each and every participant for taking the time to share their thoughts. I am also thankful of all the positive messages the participants shared with me, which helped me feel more connected to the night skies and the value they hold for individuals.

I wish to dedicate this thesis to scholars and activists around the world, young and old, who do not unquestionably accept the status quo but instead seek to change it when it is wrong, who do not give up despite all the incentives and pressures for doing so, and who dare to envision and talk about a better future for all. I would like to thank my mother and my spouse, who inspired me to keep asking “why” but also “why not?”. These two people had a particularly decisive role in inspiring me at very different times in my life to pursue a career in science, without whom this work would not have happened: Thank you, Professor Paul Sutton, for inspiring change through your influential works and (most of the time) for providing an example of someone who saw a better future and never gave up his efforts to bring it forth.

My special thanks to the ANU for providing me with a welcoming, multicultural, vibrant, and academically rigorous platform to receive a world-leading education and, of course, a memorable experience. Finally, I would like to take this opportunity to express my sincere thanks to Kurt Fristrup for his care, support, and assistance in allowing me to pause my career and study abroad in hopes of making a difference.

Abstract

Light pollution is increasingly recognised as a threat to human health and wellbeing as well as a threat to many ecosystem functions and services. Light pollution is increasing by over 2% per year. This is despite (and occasionally because of) new technology aimed at reducing light pollution (e.g. LEDs). Natural night skies (natural darkness) is the natural resource affected by light pollution. Effective stewardship of natural night skies is a challenging problem at the nexus of science, policy, communication, coalition building, monitoring, and enforcement. This work builds on the existing body of literature documenting these problems by developing solutions that effectively communicate the value and importance of natural night skies through valuation, community engagement, and educational interventions to enhance the appreciation of natural night skies. Natural night skies are a characteristic of functioning ecosystems, and thus contribute to how well ecosystem's function and the ecosystem services they provide.

This research will address three major questions: (1) Can night sky quality be effectively incorporated into existing global ecosystem service valuations? (2) What are the incentives and barriers to engaging local communities in natural night sky support? (3) Can educational interventions on natural night skies improve ecological literacy and change attitudes about nature via natural night skies? The results presented in this thesis suggest that light pollution degrades the value of ecosystem services by roughly \$3.4 Trillion per year globally. I also found that protecting the night skies is supported by the public for many reasons including the following: save money, protect human health, preserve ecosystem function, protect wildlife, provide important cultural and aesthetic experiences including fostering a sense of awe. This public support makes possible the implementation of public policy aimed at preserving the night skies. Education and experiential interventions show the potential for increasing ecological literacy related the nocturnal environment and human connection with nature.

This research explored global, local, and individual values of natural night skies. It includes economic valuation, studies of community engagement in protecting natural night skies, and educational interventions, all aimed at better understanding natural night skies at different scales and with different approaches.

Table of Contents

Chapter 1	Introduction.....	1
1.1	Abstract	1
1.2	Introduction.....	1
1.3	Impacts of Light Pollution	2
1.3.1	Impacts of light pollution on Human Health.....	5
1.3.2	Light Pollution Impacts on Wildlife	7
1.3.3	Light Pollution impacts on vegetation and ecosystem function.....	8
1.4	Sensory Ecology.....	10
1.5	Shifting Baseline Syndrome.....	11
1.5.1	Shifting Baseline Syndrome with respect to Natural Night Skies	12
1.5.2	Policy Challenges	12
1.6	Research Objectives	13
1.6.1	Thesis Structure.....	14
Chapter 2	Background.....	16
2.1	Abstract	16
2.2	Prehistoric Understanding of the Night Sky.....	16
2.2.1	Cognitive Perspective	16
2.2.2	Religious Perspective.....	17
2.2.3	Scientific Perspective	17
2.2.4	Dark Night Skies.....	17
2.2.5	Evolution and Cultural Impact.....	17
2.3	Historic Understanding of the Night Skies	18
2.3.1	Babylonian Astronomy	18
2.3.2	Egyptian Astronomy	19
2.3.3	Greek Astronomy	19
2.3.4	Roman Astronomy.....	19
2.3.5	European Astronomy and The Copernican Revolution.....	20
2.3.6	Chinese Astronomy	21
2.3.7	Modern Reverberations	22
2.4	Contemporary Indigenous Astronomical Perspectives.....	22
2.4.1	Astronomical perspectives of the Indigenous People of Australia	23

2.4.2	Mother Earth, Father Sky and the Astronomical perspectives of Native Americans.....	23
2.4.3	Astronomical perspectives of Polynesians.....	24
2.5	Looking up at the Starry Night, feeling Awe, and gaining humility	25
2.5.1	Starry Nights and the Sense of Awe	25
2.5.2	Does a sense of ‘Awe’ inspire a sense of humility?	26
Chapter 3	The Ecological Economics of Light Pollution: Impacts on Ecosystem Service Value.....	28
3.1	Abstract	28
3.2	Introduction.....	28
3.2.1	Human Health Impacts of Light Pollution	28
3.2.2	Ecological Impacts of Light Pollution.....	29
3.2.3	Light Pollution as a negative impact on Ecosystem Service Value	29
3.3	Data and Methods.....	30
3.3.1	Data	30
3.3.2	Methods	32
3.4	Results and Discussion	35
3.5	Conclusion	39
Chapter 4	Policy Implementation through Community Engagement	40
4.1	Abstract	40
4.2	The Beginning: Finding a Community	40
4.3	Establishing the Carrickalinga Dark Sky Committee (CDSC).....	42
4.4	Public Policy – the long and winding road to passing a lighting ordinance	43
4.5	Community Consultation	44
4.6	Passing the Lighting Ordinance	45
4.7	The International Dark Sky (IDA) Application	46
4.8	Conclusion	46
Chapter 5	Protecting natural night skies by improving ecoliteracy and nature-connectedness.....	48
5.1	Abstract	48
5.2	Introduction.....	48
5.2.1	Why nature connectedness is important.....	51
5.2.2	Why we should be concerned about ecological literacy	52
5.2.3	Building Curiosity, Understanding and Connection with the Night Sky.....	54
5.3	Methods	54
5.4	Results	56

5.4.1	Baseline Measures of Ecoliteracy.....	56
5.4.2	Baseline measures of ‘Connectedness to Nature’	56
5.4.3	Effects of Video Intervention on Ecoliteracy Score and ‘Connectedness to Nature’	58
5.4.4	Effects of Stargazing Intervention on Ecoliteracy Score and ‘Connectedness to Nature’	59
5.4.5	Combined Effects of Video and Stargazing Intervention on Ecoliteracy Score.....	60
5.4.6	Combined Effects of Video and Stargazing Intervention on Connectedness to Nature Score.....	62
5.4.7	Written Comments in response to queries in the stargazing exercise	63
5.5	Discussion and Conclusion	70
Chapter 6	Conclusion	72
6.1	Abstract	72
6.2	Background Summary of Research Questions	72
6.3	Main Findings: Individual Scale	73
6.4	Main Findings Community Scale	74
6.5	Main Findings Global Scale.....	74
6.6	Future Research	75
6.6.1	Quantifying Light Pollution Levels.....	75
6.6.2	Ecological Impacts	75
6.6.3	Human Health Outcomes	76
6.6.4	Cultural and Societal Impacts.....	76
6.6.5	Mitigation Strategies	76
6.6.6	Technological Innovations.....	76
6.6.7	Climate Change	77
6.7	Summary	77
References		78
Appendix 3.1	Extent of lost ESV by country	3.1-1
Appendix 4.1	Lighting Ordinance	4.1-1
Appendix 4.2	Carrickalinga International Dark Sky Association Community Application ...	4.2-1
Appendix 4.3	The survey instrument for a dark sky community	4.3-1
Appendix 4.4	Frequently Asked Questions and Answers	4.4-1
Appendix 5.1	Pre- Post- Intervention Survey	5.1-1
Appendix 5.2	Ecoliteracy Intervention Form	5.2-1
Appendix 5.3	Stargazing Intervention Form	5.3-1
Appendix 5.4	Table of the Stargazing results.....	5.4-1

List of Figures

Figure 1.1: The Web of Science literature search of the term “Light pollution” from 1973 to 2023.....	3
Figure 1.2: Studied health effects of different species (adapted from Figure 5 of Svechkina, A et al., 2020).....	4
Figure 1.3: Modified primate sensory map of the extent or boundary of different senses for a primate in nature (Dominy 2001)	11
Figure 3.1: Flowchart of the processing of the Ecosystem Services value	34
Figure 3.2: Landcover, Ecosystem Service Value (ESV), and Light Pollution Degradation of ESV for a region of South Australia centred on Adelaide.	35
Figure 3.3: Dot map of ESV loss by country.	37
Figure 4.1: Photo of Fleurieau Festival booth for survey of community endorsement of Carrickalinga becoming an International Dark Sky Community	42
Figure 5.1: Baseline scores for Night Sky Ecoliteracy quiz	56
Figure 5.2: Baseline scores for ‘Connectedness to Nature’	57
Figure 5.3: Effects of video intervention on Ecoliteracy Quiz Score.....	58
Figure 5.4: Effects of video intervention on ‘Connectedness to Nature’	59
Figure 5.5: Effects of Stargazing Intervention on Ecoliteracy	60
Figure 5.6: Effects of Stargazing Intervention on ‘Connectedness to Nature’	60
Figure 5.7: Effects of Both Interventions on Ecoliteracy	61
Figure 5.8: Effects of Both Interventions on ‘Connectedness to Nature’	62
Figure 5.9: Wordcloud derived from the prompt: “What did you see? List the celestial object that you observed? (constellations, the space shuttle, etc).	63
Figure 5.10: Frequency graph derived from the prompt: “What did you see? List the celestial object that you observed? (constellations, the space shuttle, etc).....	64
Figure 5.11: Wordcloud derived from the prompt: “Please describe in many details as you can how finding the celestial objects made you feel?”	65
Figure 5.12: Frequency graph derived from the prompt: “Please describe in many details as you can how finding the celestial objects made you feel?”	66
Figure 5.13: Responses to questions about prior and future experiences of stargazing.	67

List of Tables

Table 3.1: Ecosystem Service Values associated with aggregated PROBA-V Global Landcover Database categories (Costanza et al, 2014).....	31
Table 3.3: ESV losses from light pollution by landcover	36
Table 4.1: Response Summary from Farmer Market Visitors	41

Chapter 1 Introduction

1.1 Abstract

Chapter 1 serves as a literature review of research in the area of light pollution as it impacts human health and ecosystem function. Light pollution studies fall into the broader category of sensory ecology. Sensory ecology is the study of how organisms acquire, process, and respond to information from their environment. Humans and many other organisms are significantly impacted by sensory pollutants. Sensory pollutants can be efficiently reduced at their sources, and such reductions offer underutilised opportunities for immediate habitat restoration and improved ecosystem resilience. In the case of light pollution, the benefits are substantial, and the costs are minimal. Despite the benefits of reducing artificial light at night it continues to grow globally. Light pollution is currently increasing at a rate of 7-10% per year which represents a doubling every 7-10 years. The pace at which light pollution is increasing motivates questioning the impacts of shifting baseline syndrome on the individual and collective experience of light pollution impacts. Shifting baseline syndrome is a gradual change in the accepted norms for the condition of the natural environment due to a lack of past information or lack of experience of past conditions. Currently, 80% of the world's population lives in a light polluted place. The chapter ends with research questions that interrogate how we might value natural night skies at global, community, and individual scales.

1.2 Introduction

Sensory ecology, within the context of light pollution and shifting baseline syndrome, explores how artificial lighting affects the sensory perception and behaviour of organisms while considering the evolving reference points for what is considered "normal" (Burnett, 2011; Paul, 1995). Light pollution disrupts the natural sensory environments of countless species, influencing their ability to navigate, communicate, and interact with their surroundings (Dominoni, 2020). As the intensity of artificial light continues to increase globally, organisms experience altered sensory landscapes, impacting their ecological interactions and behaviours. Shifting baseline syndrome, on the other hand, refers to the gradual shift in perceptions of what is considered a baseline or normal state for ecosystems due to long-term environmental changes (Soga & Gaston, 2018). In the case of light pollution, this syndrome manifests as a generational amnesia where each successive generation perceives the progressively brighter night skies as the new norm, potentially underestimating the ecological consequences of altered light environments. Sensory ecology provides a valuable framework for understanding and mitigating the impacts of light pollution on organisms and ecosystems,

emphasizing the importance of preserving natural sensory conditions and acknowledging the potential long-term consequences of shifting baselines (Mappes & Stevens, 2010).

1.3 Impacts of Light Pollution

The introduction of electric light especially at night has revolutionized human existence (Falch et al., 2011). The quality of life for human beings has enhanced with artificial light at night through improved productivity, convenience, and overall comfortable (Wang et al., 2023). Nighttime lights that illuminate outdoors extend work, leisure, and mobility (Wang et al., 2023). However, excessive and poorly designed lighting at night produces light pollution. Light pollution, an environmental concern that has gained recognition over the years, has roots in scientific literature dating back to the early 1970s when the first peer-reviewed articles addressing this issue emerged. Walker (1973) and Hoag et al., (1973) were among the pioneers in acknowledging and studying light pollution, with a primary focus on its impact on astronomical observatories. Initially, astronomers were at the forefront of identifying 'light pollution' as a problem, recognizing its potential to interfere with celestial observations (Walker, 1973).

More recently, there has been a paradigm shift in how we perceive and address light pollution. Scientists and resource managers have expanded their perspective, recognizing the significance of preserving 'natural night skies' as a valuable and natural resource (Abraham et al., 2019). This shift reflects an increasing awareness of the broader implications of light pollution in addition to its impact on astronomical observations. The impacts of light pollution, more recently termed artificial light at night (ALAN), have disruptions that affect human health, plants, animals, and ecosystems (Falcon et al., 2020; Eggleton 2020; Svechkina et al., 2020; Sanders et al., 2018). There has been a fivefold increase in the research articles published and accessed in Web of Science (Figure 1.1).

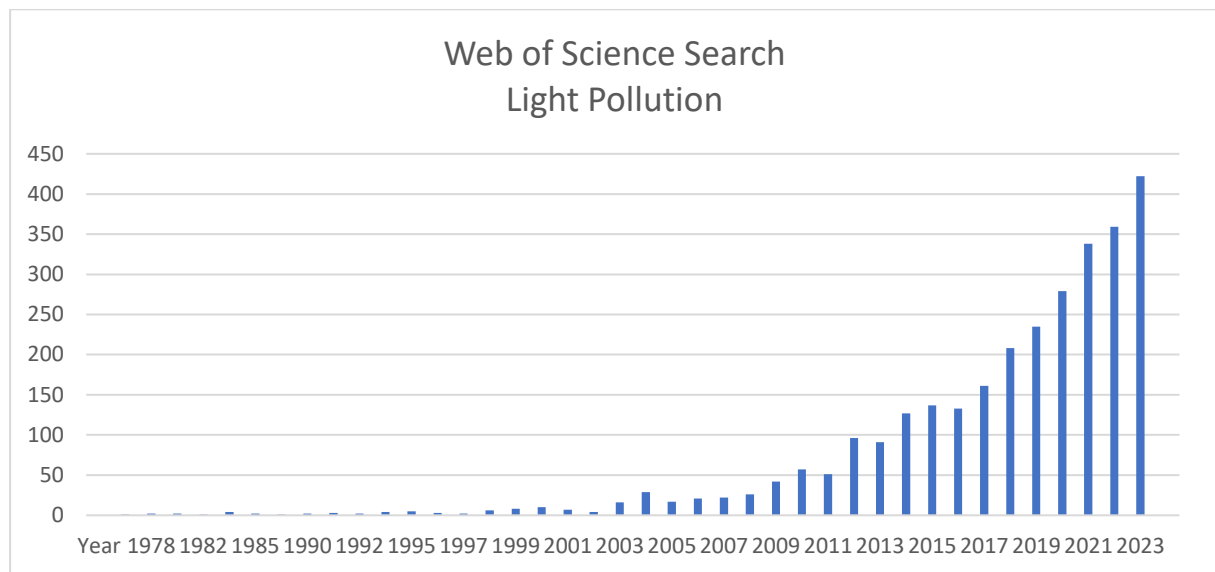


Figure 1.1: The Web of Science literature search of the term “Light pollution” from 1973 to 2023.

Research on light pollution has unveiled its profound effects on both human health and ecological systems. Studies reviewed and summarised by Svehkina et al. (2020) have highlighted the significant consequences of light pollution, including sleep disruption, melatonin suppression, and hormonal imbalances in humans, wildlife and ecosystems (Figure1.2). These findings emphasise the need for a holistic approach to address light pollution, considering its multifaceted impact on human well-being and wildlife.

Research subject	Tumors	Weight gain/ feeding behavior	Depression / Sleep disorder	Locomotion/ orientation/ trajectory	Reproductive output / pollination
					
					
					
					
					
					

 - Strong effect found;
 - Probable effect found;
found

 - Effect not studied;
 - Partial/ inconsistent effect

Figure 1.2: Studied health effects of different species (adapted from Figure 5 of Svechkina, A et al., 2020)

Moreover, the ecological ramifications of light pollution are extensive and varied. documented numerous ecological impacts, ranging from sea turtle survival to the ecological trapping of insects (Marangoni et al., 2022; Knop et al., 2017; Sanders et al., 2021). Light pollution disrupts the natural navigation patterns of animals, affecting their ability to find food, mates, and suitable habitats. The intricate balance of predator-prey relationships is also disturbed by the artificial illumination of the night sky (Minnaar et al., 2015).

One of the critical ecological impacts of light pollution is its interference with the diurnal cycle, a fundamental aspect that has guided evolution since time immemorial (Cox & Gaston, 2023). The natural progression of day and night has been intricately woven into the fabric of life on Earth, shaping the behaviour and physiology of countless species including humans (Sanders et al., 2021; Zeman, 2023). The disruption of this biological rhythm by artificial light sources poses a threat to the very essence of the evolutionary processes that have shaped the biodiversity we observe today.

Beyond its direct effects on flora and fauna, light pollution has broader implications for ecosystem services provided by a natural night sky (Jagerbrand & Spoelstra, 2023). The unaltered darkness of the night sky plays a crucial role in maintaining the balance of ecosystems. Nocturnal pollinators, for instance, rely on natural darkness to carry out their essential functions, contributing to the pollination of plants and the production of fruits and seeds (Owens et al., 2020). Artificial light at night disrupts nocturnal pollination networks and has negative consequences for plant reproductive success (Knop et al., 2017; Bucher et al., 2023).

In the realm of environmental conservation, policymakers and scientists have historically focused on tangible ecosystem services, often neglecting the importance of sensory resources (Georgiou et al., 2023; Dyer et al., 2023). The experience of a natural night sky, free from the intrusion of artificial light, is an intrinsic part of our collective human heritage (Hamacher et al., 2024). However, as urbanization and technological advancements continue to spread artificial illumination, this sensory resource is increasingly threatened (Fachi et al., 2016).

Recognizing the importance of preserving the sensory experience of a natural night sky, advocacy for responsible outdoor lighting practices has gained momentum (Ditmer et al., 2021; Kyba et al., 2023). Communities around the world are taking steps to implement lighting ordinances and guidelines that promote energy-efficient and minimally intrusive outdoor lighting (DSI, 2023; IES, 2020). Such initiatives not only mitigate the immediate impacts of light pollution but also contribute to broader efforts to create sustainable and resilient urban environments.

1.3.1 Impacts of light pollution on human health

Light pollution has notable and adverse impacts on mental health. First and foremost, exposure to bright artificial light during the night can disrupt circadian rhythms, the internal biological clock that regulates sleep-wake cycles (Davis et al., 2023). The disruption of these essential rhythms can lead to sleep disorders, such as insomnia, as well as disturbances in mood and overall mental well-being (Wang et al., 2023). The consistent exposure to artificial light, particularly from sources like streetlights and electronic devices, can interfere with the production of melatonin, a hormone crucial for regulating sleep, potentially contributing to increased stress and anxiety levels (Zeman et al., 2023).

In addition to the direct physiological impacts, light pollution can influence mental health by increasing the risk of depressive disorders (Tancredi et al., 2022). The degrading of the night sky's celestial wonders not only deprives individuals of the aesthetic and spiritual experience

of stargazing but also disconnects them from a sense of awe and wonder associated with the vastness of the universe (Clark, 2020; Hamacher et al., 2023). This detachment from the natural rhythms and beauty of the night sky can contribute to a sense of alienation and disconnection, potentially fostering feelings of isolation and loneliness. In turn, this diminished connection to the natural world may contribute to a decline in mental health by reducing opportunities for reflection, relaxation, and a sense of belonging within the broader context of the cosmos (Kaplan, 1995; Falchi et al., 2019)

Light pollution also has notable and far-reaching impacts on human physical health. One of the primary concerns is its interference with the circadian rhythm, the internal biological clock that regulates the sleep-wake cycle (Davis et al., 2023). Exposure to artificial light during the night, particularly blue light emitted by electronic devices, can suppress the production of melatonin, a hormone essential for promoting sleep. The disruption of sleep patterns, commonly associated with light pollution, is linked to a myriad of health issues, including an increased risk of cardiovascular diseases, metabolic disorders, and compromised immune function (Wang et al., 2023).

Furthermore, light pollution has been implicated in the exacerbation of pre-existing conditions such as insomnia and sleep disorders. Prolonged exposure to bright artificial light, especially in urban areas where light pollution is prevalent, can lead to chronic sleep deprivation. This, in turn, heightens the risk of developing conditions like obesity, diabetes, and hypertension (Koo et al., 2016; Obayashi et al., 2014). The disturbed sleep patterns induced by light pollution have been identified as a significant factor in the overall deterioration of physical health, contributing to a cascade of adverse effects on the cardiovascular and metabolic systems (Davis et al., 2023).

Beyond sleep-related concerns, light pollution has implications for cancer, hormonal balance and overall well-being (Kamyab et al., 2023; Zeman et al., 2023). Exposure to artificial light at night can disrupt the natural production of hormones such as cortisol and adrenaline, which play crucial roles in the body's stress response. The persistent elevation of stress hormones due to light pollution may contribute to heightened stress levels, anxiety, and an increased susceptibility to stress-related illnesses (Lui et al., 2023). In essence, the pervasive nature of light pollution not only compromises sleep quality but also has broader implications for various physiological systems, significantly influencing human physical health (Liu et al., 2023).

1.3.2 Light Pollution Impacts on wildlife

Light pollution also has been demonstrated to have profound and often detrimental effects on wildlife (Gaston et al., 2013). Notable impacts include the disruption of natural behaviors and ecological processes (Longcore & Rich, 2004). Nocturnal animals, which rely on darkness for activities such as hunting, mating, and navigation, are particularly vulnerable (Dananay & Benard, 2018; Stone et al., 2015; Cabrera-Cruz et al., 2013; Horton et al., 2023). Artificial lights interfere with their natural rhythms, causing disorientation and difficulty in finding food or mates (Longcore & Rich, 2004). This disruption can lead to changes in species distribution and population dynamics and even impact the composition of ecosystems.

For many species, light pollution affects the critical process of reproduction. Sea turtles, for instance, are known to be heavily affected by coastal lights that can disorient hatchlings, leading them away from the ocean and into dangerous terrestrial environments (Peregrym et al., 2023; Witherington & Bjorndal, 1991). Sea turtles nesting is also disrupted by artificial light at night on the coast (Mazor et al., 2013). Similarly, some bird species use celestial cues for navigation during migration, and bright urban lights can lead them astray, causing collisions with buildings and other hazards (Spoelstra & Visser, 2023). The altered reproductive behaviors and migration patterns of wildlife due to light pollution can have cascading effects on population sizes, genetic diversity, and the overall health of ecosystems (Spoelstra & Visser, 2023; Horton et al., 2023).

Light pollution also disrupts the delicate balance of predator-prey interactions (Miller et al., 2017). For instance, prey species may become more visible under artificial lights, making them easier targets for nocturnal predators (Ditmer, 2021). This can result in population imbalances, affecting not only the prey and predator species directly involved but also the entire ecosystem. In marine environments, artificial lights along coastlines can attract and disorient wildlife, disrupting the food chain and affecting larger marine animals that depend on them (Mariangoni et al., 2022).

In addition to direct ecological impacts, light pollution poses threats to various wildlife species through physiological changes. The circadian rhythms and hormonal cycles of many animals, including insects, amphibians, and mammals, are influenced by natural light patterns (Firebaugh & Haynes, 2019; Touzot et al., 2020; Le Tallec et al., 2013). Artificial lights can disturb these rhythms, leading to altered hormone levels, disrupted feeding patterns, and compromised immune systems (Dominoi, 2015). This physiological stress may weaken

individuals and populations, making them more susceptible to diseases and reducing their overall fitness (Kernback et al., 2021).

Mitigating the impacts of light pollution on wildlife requires a multi-faceted approach (Ganguly & Candolin, 2023; Rodrigo-Comino et al., 2023). Implementing responsible outdoor lighting practices, such as using shielded fixtures and motion sensors, can minimise the negative effects. Public awareness campaigns and community initiatives are essential in encouraging the widespread adoption of light-friendly policies (Brilliel et al., 2023; DSI, 2023). Legislation and regulations at various levels can play a crucial role in enforcing responsible lighting practices and protecting wildlife habitats from excessive light intrusion (Pothukuchi, 2023). By addressing light pollution comprehensively, we can better preserve the natural behaviors, reproductive processes, and ecological interactions that define the diverse array of wildlife on our planet.

1.3.3 Light Pollution impacts on vegetation and ecosystem function

Light pollution has profound impacts on vegetation and ecosystem function. One of the primary consequences is the disruption of natural light cycles, affecting the behaviour of plants and animals thus the ecosystem (Katabora et al., 2022). For vegetation, the alteration of the photoperiod, the duration of light and dark periods in a day, can disrupt crucial processes such as growth, flowering, and fruiting (Viera-Perez et al., 2019). Many plants rely on the natural cues of light and darkness to regulate their life cycles, and light pollution can lead to mismatches in these cycles, potentially reducing overall plant productivity (Sander et al., 2021; Meng et al., 2022; Bucher et al., 2023).

Moreover, light pollution can interfere with the process of photosynthesis, a fundamental mechanism by which plants convert light energy into chemical energy (Bucher et al., 2023). Artificial light at night can inhibit photosynthesis by suppressing the production of chlorophyll and disrupting the balance of various plant hormones (Poulin et al., 2014). This interference can hinder the overall health and vitality of vegetation, affecting plant communities and the organisms that depend on them. Additionally, changes in the availability of light can impact the phenology of plants, altering the timing of key events like bud burst and leaf senescence, which can have cascading effects throughout the ecosystem (Viera-Perez et al., 2019).

The impacts of light pollution extend beyond individual plants to entire ecosystems (Bara & Falchi, 2023). Nocturnal animals, including insects, birds, and mammals, are often drawn towards artificial lights, leading to changes in their behaviour and distribution (Gaston et al., 2014; Levy et al., 2020; Longcore & Rich, 2004). This can disrupt predator-prey relationships,

alter pollination dynamics, and even contribute to changes in species composition within ecosystems (Lewanzik & Voigt, 2014). For example, certain nocturnal pollinators may be attracted to artificial lights, reducing their effectiveness in pollinating plants that bloom during the night. Such disruptions can have far-reaching consequences for ecosystem structure and function (Bennie et al., 2015).

Furthermore, the increased illumination of urban areas due to light pollution can create "skyglow," a phenomenon where the night sky becomes brighter, even in remote areas (Jechow et al., 2020; Duriscoe et al., 2018). Skyglow can impact the natural behaviours of various organisms, including those that navigate using celestial cues such as stars or the moon (Wilson et al., 2021). For species that rely on these cues for migration, foraging, or reproduction, the altered night sky can lead to disorientation and increased vulnerability to predation (Foster et al., 2021; Horton et al., 2023).

In conclusion, light pollution poses significant threats to vegetation and ecosystem function by disrupting natural light cycles, hindering photosynthesis, altering plant phenology, and impacting the behaviour of nocturnal species (Poudin, 2014; Le Tallec et al., 2013). As urbanization and artificial lighting continue to expand, addressing and mitigating the impacts of light pollution becomes crucial for preserving the integrity and health of ecosystems worldwide (Kyba et al., 2023; Barentine et al., 2018; Hölker et al., 2023). Conservation efforts and responsible lighting practices are essential to minimise these negative effects and promote the sustainable coexistence of human activities and the natural environment (Ditmer et al., 2021; Rowe et al., 2015).

In conclusion, the awareness of light pollution has evolved significantly since its initial recognition in the 1970s as seen in the growth of literature (Figure 1.1). From being primarily associated with its impact on astronomical observations, the understanding of light pollution has expanded to encompass its far-reaching consequences on human health, ecological systems, and the whole of the natural world (Dimovski et al., 2023; Ditmer et al., 2021; Bara & Falchi, 2023). As we grapple with the challenges of preserving our environment in the face of rapid urbanization and technological progress, the battle against light pollution emerges as a crucial frontier in environmental conservation (Kernbach et al., 2021). Only through concerted efforts, involving policymakers, scientists, and the general public, can we hope to restore and protect the invaluable resource of a natural night sky for generations to come (Pothukuchi, 2023; Holker et al., 2010; Davie & Smyth, 2018).

1.4 Sensory Ecology

Sensory ecology is a relatively new branch of ecology. It is the study of the interface of animals' senses and their environments; more specifically, how the central nervous system of organisms and their environment interact (Dangle et al., 2009). In 2001, Dominy (2001) developed a map of the sensory abilities of primates when searching for food (Figure 1.3). The map has the touching boundary, smelling boundary, seeing boundary, hearing boundary, and remembered space areas. These sensory maps vary for individual species and have different impacts on species behaviour. Nonetheless, these sensory 'spaces' are essential to consider when trying to restore or preserve an ecosystem (Dangle et al., 2009).

Ecologists have also studied the cost and benefit to species of retrieving and using information about their environment and the on-going trade-offs organisms have with sufficient and reliable information. As with humans, wildlife needs to save energy and often time (Schneeberger & Taborsky, 2020). Pollutants interfere with information gathering and have shown to cause declines in biodiversity, health, and success of species. However, the study of how organisms interact and perceive their environments with and without pollutants is often overlooked by scientific studies (Mayo & Ng, 2016). Sensory ecology is the interface between senses and environment which provides the information available to animals from the biotic and abiotic environment (Mappes & Stevens, 2010). This subdiscipline also explores how this information is captured and processed. For a fully functioning ecosystem the sensory resources need to be accounted for, especially in ecosystem service valuation. The natural night sky is a resource that is essential from an evolutionary perspective and is at the centre of this research (Johnsen, 2012; Davis & Smyth 2018).

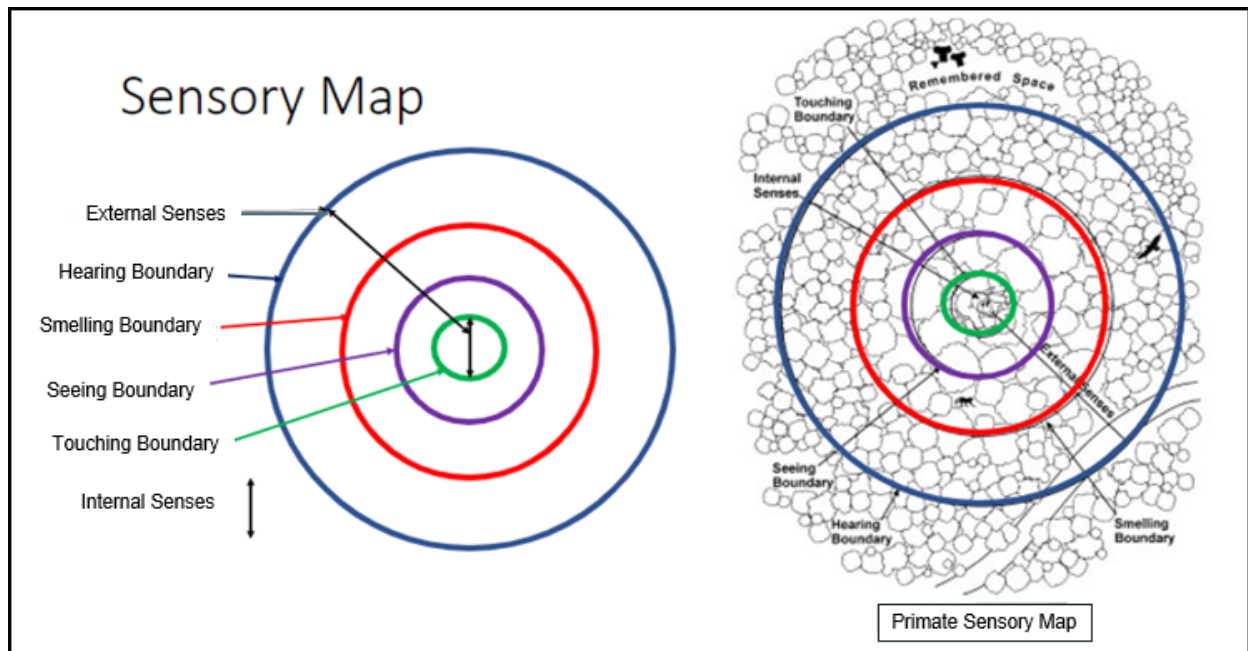


Figure 1.3: Modified primate sensory map of the extent or boundary of different senses for a primate in nature (Dominy 2001)

1.5 Shifting Baseline Syndrome

Shifting baseline syndrome refers to a gradual and often unnoticed change in the perception of what is considered normal or baseline in environmental conditions over time (Soga & Gaston, 2018, Alleway et al., 2023). Coined by marine biologist Daniel Pauly in the context of fisheries (Pauly, 1995), the concept has broader applications in various ecosystems. As generations succeed one another, each may accept a degraded environmental state as the new normal, underestimating the extent of change that has occurred (Alleway et al., 2023). This phenomenon has implications for conservation efforts, as it may lead to a lack of recognition of historical losses in biodiversity or ecosystem health (Papworth et al., 2009). Shifting baseline syndrome highlights the importance of understanding and preserving the original ecological context to avoid a continuous decline in environmental quality and to promote more effective conservation and restoration strategies. It underscores the need for interdisciplinary efforts to bridge the gap between scientific knowledge, public awareness, and policy-making to address and reverse the often imperceptible but cumulative degradation of our natural environments (Paramesh & Sankam, 2023).

1.5.1 Shifting Baseline Syndrome with respect to natural night skies

Shifting baseline syndrome is particularly poignant when considering the night sky and the pervasive issue of light pollution. Many individuals today are growing up in urban and suburban environments where artificial lights drown out the natural brilliance of the night sky (Kyba et al., 2022; Falchi et al., 2016). The stars, once a prominent and awe-inspiring feature of the nocturnal landscape, have become obscured by the glow of city lights. This shift in baseline perception means that newer generations may not fully appreciate the profound beauty and celestial wonders that were once visible to their ancestors. The night sky, now tainted by light pollution, is increasingly accepted as the norm, and individuals may be unaware of the depth of loss in terms of both cultural and ecological significance.

Moreover, shifting baseline syndrome in the context of light pollution can lead to a cycle of escalating artificial illumination. As each generation becomes accustomed to brighter night skies as the new standard, there is a tendency to perpetuate and even intensify the use of artificial lights (Falchi et al., 2016). This normalization of excessive illumination exacerbates the detrimental effects on ecosystems, disrupting wildlife behaviour, affecting human health, and contributing to the global loss of natural darkness (Bara & Falchi, 2023). Recognizing the implications of shifting baseline syndrome in the context of light pollution is crucial for fostering awareness, inspiring advocacy, and implementing effective measures to restore and protect natural night skies for current and future generations (Hamacher et al *in press*).

1.5.2 Policy challenges

Policy development for light pollution faces significant challenges due to shifting baseline syndrome, as the evolving perception of what constitutes acceptable levels of artificial lighting hinders the establishment of effective regulations (Lyytimäke & Rinne, 2013). As successive generations become accustomed to increasingly illuminated nightscapes, there is a risk of normalizing the adverse impacts of light pollution. Decision-makers, often influenced by the shifting baseline, may underestimate the severity of the problem and fail to recognise the ecological, cultural, and health-related implications of excessive artificial lighting (Olsen et al., 2014).

Moreover, shifting baseline syndrome complicates the task of setting ambitious and proactive policy goals as does the capitalist transformation of the nocturnal realm. (Gandy, 2017). Individuals who have grown up in environments saturated with artificial light may lack a firsthand appreciation for the natural darkness that is increasingly rare and may believe that light at night is part of modern society and their lives (Kamrowski et al., 2015). This lack of

personal experience with pristine night skies may lead to a diminished sense of urgency in advocating for robust policies against light pollution. As a result, there may be resistance to implementing stringent measures that would restore and protect the original, darker nightscapes. Addressing light pollution requires policy-makers to recognise and challenge shifting baselines, advocating for regulations that aim not just to maintain the current compromised state but to actively restore and preserve the natural darkness that is an integral part of our planet's biodiversity and cultural heritage (Gaston, 2015; Kyba et al., 2022). Mitigating light pollution will also require a multifaceted approach (Paramesh & Sankam, 2023).

1.6 Research objectives

This thesis explores the value of natural night skies. The natural diurnal cycle of night and day is a fundamental element driving the biological evolution of plants, ecosystems, and animals, including humans. Human cognition of our science, religion, and place in the universe has been informed by celestial observations. Light pollution is degrading the value of natural night skies at an alarming rate. This thesis explores the public policy implications of the alarming growth of artificial light at night at global, community, and individual scales. The overarching research question is: How does light pollution impact natural night skies' ability to contribute to ecosystem services and human wellbeing at multiple scales?

In an effort to address the overarching question at multiple scales, my chapters will address the following research questions:

GLOBAL (Chapter 3)

How can you frame natural night skies as an attribute of the ecosystem that can inform the valuation of ecosystem services?

How do you incorporate the global ecosystem services losses due to ALAN?

How does ALAN affect the dollar values of the global ecosystem services?

COMMUNITY (Chapter 4)

What arguments have the most traction for garnering public support for the establishment of a dark sky community?

Which of the six benefits of a dark sky community listed below are supported by the residents, businesses, and government for formal adoption of a dark sky community certification?

- 1) Save money
- 2) Improve Human Health
- 3) Enhance Public Safety
- 4) Healthy Planet makes Healthy People
- 5) Cultural / Heritage / History Benefits
- 6) Tourist Economy

What are the steps needed to implement a lighting policy at the local government level that supports the application to the IDA for an International Dark Sky Community?

INDIVIDUAL (Chapter 5)

What impacts does a natural night skies educational intervention have on individual measures of ecoliteracy and 'connectedness to nature'?

1.6.1 Thesis structure

Chapter 1 presents an overview of research documenting the impacts of light pollution on wildlife, ecosystem function, and human health. Sensory ecology is then used to understand the impacts of light pollution. This is followed by a summary of how 'shifting baseline syndrome' impairs our ability to recognise and address the problems of light pollution, and finally, this summary of the thesis.

Chapter 2 summarises the history of our evolving interest in, and utilization of, natural night skies. The chapter starts with the prehistoric understanding and the importance of the cosmos. The importance of the night skies and human curiosity led to different perspectives through the development of scientific methods and through modern reverberations. The background includes Indigenous perspectives from Indigenous Australians and Native Americans and ends with the Polynesian's use of night skies knowledge for navigation. Throughout time the natural night skies have been a source of profound wonder and awe.

Chapter 3 provides a global estimate of the dollar cost of light pollution in terms of degraded ecosystem service value. Global maps of ecosystem service value are degraded using a global map of artificial light at night. This produced an estimate of a \$3.4 trillion / year loss of ecosystem service value due to light pollution which is roughly 3% of the global GDP in 2022.

Chapter 4 is public policy piece describing a community-engaged scholarship effort to establish Australia's first International Dark Sky community in Carrickalinga, South Australia. This chapter tells the story of how community engagement with one community went from enjoying

the night skies to protecting their town's current natural night skies. This journey involved many steps ranging from establishing a stable backbone organization, creation of a Dark Sky Committee, passing a lighting policy to writing a full application to the International Dark Sky Association for certification.

Chapter 5 describes an experiment that evaluates individual 'connectedness to nature' and ecological literacy associated with natural night skies. This was an experiment with human subjects at a university in the United States (University of Denver) and a university in Australia (University of South Australia). Objective tests of ecological literacy and measures of 'connectedness to nature' were performed before and after interventions involving educational videos and stargazing experiences. Statistical analysis showed that the videos improved ecological literacy scores whereas the 'connectedness to nature' impacts were not as strong.

Chapter 6 summarises the aforementioned from the perspective of varying scales of analysis from individual to community to global. The chapter concludes with suggestions for future research.

Chapter 2 Background

2.1 Abstract

The evolution of human use and understanding of the night skies resulted from our observations of celestial phenomena that influenced our ability to survive, navigate, and develop our scientific and religious understandings (Ruggles, 2005). Natural night skies have served as a valuable guide in developing our understanding of our place in the world, the world itself, and the world's place in the universe. However natural night skies are disappearing (Falchi et.al., 2016). Thus, the following is a brief sketch of pre-historic, historic, and contemporary indigenous peoples use, understanding, and valuation of natural night skies. This chapter concludes with some speculation as to how observation of natural night skies stimulates an 'awe' that supports the development of humility.

2.2 Prehistoric understanding of the night sky

As prehistoric societies evolved, so did their understanding of celestial phenomena. Celestial observation's cognitive, religious, and scientific aspects combined, influencing cultural beliefs, societal structures, and technological advancements (Hutton, 2014; Sweatman & Coombs, 2018). The legacy of prehistoric stargazers endures in modern civilisations' cultural and scientific practices, underscoring the enduring impact of our ancestors' fascination with the celestial realm (Szucs-Csillik, 2021; Sinha, 2019). Today, as we gaze into the same night sky, we continue to inherit and build upon the foundations laid by prehistoric humans, appreciating the cosmos' beauty, mystery, and complexity (Clark, 2020).

2.2.1 Cognitive perspective

The cognitive aspect of prehistoric human understanding of celestial observation is rooted in the fundamental need for survival, adaptation and monitor time (Marshack, 1972). Early humans, lacking sophisticated tools, relied on keen observations of celestial bodies to comprehend time, seasons, and natural cycles. This ability still exist in parts of the world today (Sinha, 2017). This cognitive development was crucial for activities such as hunting, agriculture, and migration (Williamson & Farrer, 1994). The ability to recognise celestial patterns showcased early human intelligence and adaptability. As they discerned the regularities in the movement of the sun, moon, and stars, these observations became integral to their daily lives and contributed to the evolution of cognitive abilities.

2.2.2 Religious perspective

In the religious context, the prehistoric era witnessed the birth of mythologies and spiritual beliefs intricately woven around celestial events (Couprie, 2011). The consistent and predictable nature of celestial phenomena led many ancient cultures to associate these occurrences with divine forces (Makemson, 1954). The sun, moon, and stars were often deified, with cultures attributing cosmic events to the actions of gods or other supernatural entities. Rituals and ceremonies became intertwined with celestial cycles, creating a sacred connection between the heavens and Earth. The night sky, unspoiled by light pollution, served as a celestial canvas for religious narratives, shaping the spiritual landscape of prehistoric societies.

2.2.3 Scientific perspective

While lacking the sophisticated tools of modern astronomy, prehistoric humans demonstrated a nascent scientific understanding of celestial phenomena. Archaeological evidence suggests the construction of structures aligned with astronomical events, such as El Castillo and El Caracol in Chichén Itzá and Stonehenge in England (Hartung, 1984; Hutton, 2015). These primitive observatories highlight an early interest in systematic observation of the cosmos. The development of rudimentary tools for measuring celestial movements and tracking astronomical events marked the beginnings of observational astronomy (Clark, 2020). Despite their limited technological resources, prehistoric humans laid the foundation for the scientific exploration of the universe.

2.2.4 Dark night skies

The dark night skies of prehistoric times played a pivotal role in shaping human perspectives (Salimpour & Fitzgerald, 2022). In the absence of artificial light pollution, the night sky was an awe-inspiring panorama filled with stars, planets, and cosmic phenomena. This unobstructed view facilitated practical aspects like navigation for ancient seafarers and nomads and inspired creativity and imagination (Clark, 2020). The celestial sphere became a source of mythic stories, influencing art, literature, and cultural symbolism. The prehistoric night sky served as a powerful source of inspiration, fostering a profound connection between early humans and the mysteries of the cosmos.

2.2.5 Evolution and cultural impact

As prehistoric societies evolved, their understanding of celestial observation deepened. The cognitive, religious, and scientific aspects became intertwined, influencing cultural beliefs,

societal structures, and technological advancements (Clark, 2020; Santoni, 2012). The legacy of prehistoric stargazers endured in the cultural practices of ancient civilizations, leaving a lasting impact on religious rituals, mythologies, and societal norms (Ruggles, 2005). As human societies progressed, so did their ability to observe and comprehend the cosmos, leading to significant contributions in the fields of astronomy and astrophysics.

2.3 Historic understanding of the night skies

Throughout history, the observation and understanding of the night skies and celestial phenomena have undergone remarkable transformations, reflecting the evolving knowledge and technological advancements of human civilizations. Ancient cultures, such as the Greeks, Egyptians, and Babylonians, made significant strides in mapping the night sky and predicting celestial events (Couprie, 2011; Hanna, 2015; Fang, 2012). The development of sophisticated tools, like the astrolabe and quadrant, facilitated more precise observations. In the medieval period, Islamic scholars preserved and expanded upon this astronomical knowledge, contributing to the Renaissance's revival of interest in celestial observation in Europe. The invention of the telescope by Galileo Galilei revolutionised astronomy in the 17th century, enabling detailed observations of celestial bodies (Machamer & Miller, 2021; Sobel, 2011). Subsequent centuries saw the formulation of laws of motion and gravitation by scientists like Isaac Newton, providing a theoretical framework for understanding celestial mechanics (Fraknoi et al., 2017). The 20th century witnessed the advent of powerful telescopes, space exploration, and advancements in astrophysics, uncovering the mysteries of the cosmos on an unprecedented scale. Today, our understanding of the night skies combines ancient wisdom with cutting-edge technology, allowing us to explore the universe with unparalleled depth and precision (Smith, 1982; Fraknoi et al., 2017).

2.3.1 Babylonian astronomy

Babylonian astronomy, flourishing in ancient Mesopotamia from the 8th to the 2nd century BCE, represents a foundational chapter in the history of observational astronomy. The Babylonians meticulously recorded celestial events, developing one of the earliest systematic approaches to studying the night sky (Rogers, 1998). Noteworthy for their accurate observations of planetary motion and the lunar calendar, Babylonian astronomers left behind an extensive collection of cuneiform tablets detailing their findings including the number of days in the year (Fraknoi et al., 2017). The Venus tablet of Ammisaduqa is a remarkable example, documenting Venus's positions over a 21-year period. Their understanding of the zodiacal constellations and the ecliptic, the apparent path of the Sun through the sky, influenced subsequent civilizations, including the Greeks (Rogers, 1998). Babylonian

astronomy laid crucial groundwork for later advancements in the field, emphasizing the importance of empirical observation in unravelling the mysteries of the cosmos.

2.3.2 Egyptian astronomy

Egyptian astronomy, rooted in the ancient civilization along the Nile River, reflects a profound intersection of celestial observations with religious and practical concerns. Predominantly focused on the solar and lunar cycles, the Egyptians developed a keen understanding of the celestial bodies' movements. The construction of monumental structures like the Great Pyramid at Giza suggests a sophisticated knowledge of astronomy, with alignments possibly serving calendrical or ritual purposes (Nell & Ruggles, 2014). The annual flooding of the Nile, vital for agriculture, was intricately linked to the heliacal rising of the star Sirius (Reed, 1986). Egyptian calendars, such as the Sothic calendar based on the Sirius cycle, underscored the fusion of astronomical understanding with agricultural and religious contexts. Overall, Egyptian astronomy showcased an integration of celestial observations into the cultural, religious, and practical facets of ancient Egyptian society (Marshall, 1989).

2.3.3 Greek astronomy

Greek astronomy, pivotal in the development of Western scientific thought, emerged during the Hellenistic period and flourished from the 6th century BCE onward. Influenced by Babylonian and Egyptian traditions, Greek astronomers like Thales, Anaximander, and Pythagoras laid the groundwork for a systematic approach to understanding celestial phenomena (Couprie, 2011). However, it was the work of luminaries such as Claudius Ptolemy and Aristarchus of Samos that marked significant strides. Ptolemy's geocentric model, presented in the "Almagest," dominated Western thought for centuries, detailing the apparent motion of celestial bodies around a stationary Earth (Reed, 1998). In contrast, Aristarchus proposed a heliocentric model, anticipating Copernicus by over a millennium. The contributions of Euclid, Hipparchus, and Eratosthenes further enriched Greek astronomy, encompassing developments in geometry, observational accuracy, and the measurement of Earth's size. Greek astronomy laid the foundation for the scientific revolution, fostering a tradition of inquiry that profoundly influenced subsequent generations of astronomers and philosophers (Library of Congress, 2024).

2.3.4 Roman astronomy

Roman astronomy, deeply influenced by Greek and Egyptian traditions, represents a continuation and refinement of earlier celestial knowledge within the Roman Empire. While the

Romans did not make groundbreaking astronomical discoveries, they contributed to the dissemination and preservation of Greek astronomical works (Bowen, 2020). Notable figures such as Ptolemy, whose "Almagest" served as a fundamental astronomical treatise, continued to be influential during this era (Fraknoi et al., 2017). The Roman use of astronomical calendars for agricultural and religious purposes showcased the practical applications of celestial knowledge in daily life. Despite not introducing revolutionary theories, Roman astronomy played a crucial role in transmitting and preserving the astronomical heritage of antiquity, paving the way for medieval and Renaissance scholars to build upon this rich tradition (Bowen, 2020).

2.3.5 European astronomy and The Copernican Revolution

European astronomy underwent a transformative period during the Copernican Revolution in the 16th century, challenging centuries-old geocentric views and setting the stage for a heliocentric model of the cosmos. Nicolaus Copernicus, a Polish mathematician and astronomer, introduced his heliocentric model in his seminal work "De Revolutionibus Orbium Coelestium" (On the Revolutions of the Celestial Spheres) in 1543. This revolutionary idea suggested that Earth and other planets orbited the Sun, fundamentally shifting the prevailing Ptolemaic geocentric system (Library of Congress, 2024). Copernicus's heliocentric model provided a simpler explanation for the observed motions of celestial bodies and laid the groundwork for a more accurate understanding of the solar system, but created other unanswered questions (Rabin, 2023)

The Copernican Revolution prompted intense scientific and philosophical debates and ignited a period of astronomical inquiry. Astronomers like Johannes Kepler, who formulated the laws of planetary motion, and Galileo Galilei, who made groundbreaking telescopic observations, provided empirical evidence supporting the heliocentric model. Galileo's discoveries, such as the phases of Venus and the moons of Jupiter, directly challenged the Ptolemaic system and reinforced the heliocentric perspective (Brown, 2016). The Copernican Revolution laid the foundation for the Scientific Revolution, fostering a spirit of inquiry and challenging traditional dogmas. The work of later astronomers, such as Johannes Kepler and Isaac Newton, further refined the heliocentric model and established a comprehensive understanding of celestial mechanics (Brown, 2016). Newton's laws of motion and universal gravitation provided a unifying framework for explaining both terrestrial and celestial phenomena, solidifying the heliocentric model as the cornerstone of modern astronomy. The Copernican Revolution not only transformed the way humanity perceived its place in the cosmos but also paved the way for the scientific method and the flourishing of modern science (Library of Congress, 2024).

2.3.6 Chinese astronomy

The historical development of astronomy in China is one that spans thousands of years, characterised by a keen observational tradition, advanced instruments, and a deep integration with Chinese philosophy and culture. Ancient Chinese astronomers were meticulous in recording celestial events, such as eclipses and comets, in early texts like the "Shi Ji" (Records of the Grand Historian) and "Shu Ching" (Book of Documents). The first distinct sunspots were recorded during the Han Dynasty (202 BCE–220 CE) (Fang, 2012).

The Chinese made significant strides in developing sophisticated astronomical instruments, such as armillary spheres and gnomons, to accurately measure celestial bodies' positions and determine the time. The "Dunhuang Star Chart," dating back to the Tang Dynasty (618–907 CE), is an early example of a comprehensive star catalogue. During the Yuan Dynasty (1271–1368 CE), Guo Shoujing's work on improving the Chinese calendar and his observatory designs demonstrated a commitment to precision (Fraknoi et al., 2017).

The Ming Dynasty (1368–1644 CE) marked a growing period for Chinese astronomy, with the construction of the Ming Observatory in Beijing and the compilation of star atlases like the "Dai Ming Xing Xiang Tu" (Star Chart of the Great Ming) (Deane, 1994). The adoption of Islamic astronomy during the Ming period also influenced Chinese astronomical methodologies. However, by the later Ming and Qing Dynasties, political instability and external pressures hindered further advancements.

In the early 17th century, Jesuit missionaries, such as Matteo Ricci, introduced European geographical and astronomical knowledge to the Chinese court, leading to a fruitful exchange of ideas (Ch'en & Ricci, 1939). This period of cultural exchange, known as the "Jesuit Missions," played a role in the introduction of Western astronomy and telescopic observations to China.

The 20th century witnessed the renaissance of Chinese astronomy, with the construction of modern observatories, participation in international collaborations, and advancements in space exploration (Guoxiang, 2003). Today, China stands as a major player in space science and astronomy, with ongoing projects like the Five-hundred-meter Aperture Spherical Radio Telescope (FAST) showcasing the country's commitment to pushing the boundaries of astronomical research. The historical development of astronomy in China reflects a continuous evolution, blending ancient wisdom with contemporary scientific endeavours (Fang, 2012).

2.3.7 Modern reverberations

The fascination with celestial observation and the night sky continues in the modern era (Clark, 2020). The cognitive, religious, and scientific perspectives of prehistoric times have shaped the way we understand and interact with the cosmos today. Advances in technology have allowed for unprecedented observations, revealing the intricacies of the universe. However, the spiritual and cultural significance of celestial events persists, with traditions, rituals, and myths echoing the timeless connection between humanity and the celestial realm. The dark night skies, though increasingly impacted by light pollution, remain a source of wonder, prompting ongoing efforts to preserve and appreciate the beauty of the natural night sky (DSI, 2023).

In conclusion, the prehistoric human understanding and use of celestial observation and the dark night skies are multifaceted, encompassing cognitive, religious, and scientific dimensions (Makemsom, 1954; Marshack, 1971). The interplay of these perspectives has left an indelible mark on human history, shaping cultural practices, belief systems, and scientific pursuits. When humans gaze into the night sky, we continue a tradition that stretches back to our prehistoric ancestors, recognizing the enduring impact of their curiosity, ingenuity, and reverence for the celestial wonders above.

2.4 Contemporary indigenous astronomical perspectives

Contemporary astronomical perspectives of indigenous people encapsulate a dynamic intersection of traditional knowledge, cultural practices, and modern scientific engagement (Ruggles, 2010). Many indigenous communities worldwide maintain a profound connection to the cosmos, grounded in centuries-old oral traditions and celestial observations (Nakata et al., 2014). Indigenous astronomy often involves a holistic perspective, intertwining celestial events with terrestrial phenomena and cultural narratives. In recent years, there has been a growing recognition of the importance of indigenous astronomical knowledge in contributing to our understanding of the universe and the historical evolution of culture (Cajete, 2009; Gianotti, et al., 2023). Collaborations between indigenous communities and astronomers aim to bridge traditional practices with modern scientific methodologies, acknowledging the unique insights indigenous perspectives can offer to fields like astrophysics and cosmology (Natata, 2014). Such collaborations foster cultural appreciation and respect for diverse ways of knowing and contribute to a more inclusive and enriched understanding of the cosmos. The following is a brief sketch of the astronomical perspectives of the indigenous people of Australia, North America, and the Pacific Islanders.

2.4.1 Astronomical perspectives of the Indigenous People of Australia

The astronomical traditions of Indigenous Australians are deeply rooted in their cultural, spiritual, and practical connections to the land and the cosmos. Indigenous Australian communities, comprising diverse cultural groups across the continent, have cultivated intricate celestial knowledge over thousands of years. Dreamtime stories, which are central to Indigenous cosmologies, often incorporate celestial elements, explaining the origins of stars, constellations, and celestial phenomena (Noon et al., 2022). Astronomical knowledge is passed down through oral traditions, with elders serving as custodians of this wisdom. Indigenous Australians have an intimate understanding of seasonal changes, navigation, and environmental cues derived from celestial observations (Noon et al., 2022). The position of stars and the movement of celestial bodies are integral to their calendars, influencing activities such as hunting, gathering, and ceremonies. For example, the celestial emu is one of the most widespread Aboriginal asterisms across Australia (Fuller et al., 2014). Additionally, rock art sites, like the Wurdi Youang stone arrangement in Victoria, serve as celestial calendars and navigation aids, attesting to the enduring importance of astronomy in Indigenous cultures (Norris & Hamacher, 2015).

In recent years, there has been a growing appreciation for the richness of Indigenous Australian astronomical knowledge within the broader scientific community. Collaborative efforts between Indigenous communities and astronomers seek to combine traditional wisdom with modern scientific methods, fostering a mutual exchange of insights. Initiatives like the "Aboriginal and Torres Strait Islander Astronomy Project" aim to document and share Indigenous astronomical knowledge while promoting cultural awareness (Hamacher, 2024). The book series *First Knowledges* published *Astronomy Sky Country* in 2022 (Noon et al., 2022). These projects contribute not only to the preservation of Indigenous Australian cultural heritage but also to a more inclusive and diverse understanding of the cosmos.

2.4.2 Mother Earth, Father Sky and the astronomical perspectives of Native Americans

The astronomical perspectives of Native American peoples are deeply rooted in a spiritual and interconnected understanding of the cosmos, often expressed through the symbolic relationship between Mother Earth and Father Sky (Williamson & Farrer, 2009). In many Native American traditions, Mother Earth is seen as a nurturing and life-giving force, embodying the physical world and the source of sustenance. Father Sky, on the other hand, represents the vast celestial realm and the spiritual dimension (Maryboy, 2020). The celestial bodies, including the sun, moon, stars, and constellations, are viewed as celestial relatives within this

cosmology (Maryboy, 2020). The cyclical movements of these celestial entities are intertwined with the cycles of nature, influencing seasonal changes, migration patterns of animals, and the timing of planting and harvesting in agricultural practices (Williamson, 1987).

This profound connection between Mother Earth and Father Sky is reflected in ceremonial rituals, stories, and art across various Native American cultures (Williamson & Farrer, 1994). The night sky, as observed from Earth, is often considered the realm of Father Sky, while the Earth is seen as a sacred and living entity deserving of reverence and protection (Kimmerer, 2015). The symbolic relationship between Mother Earth and Father Sky underscores the holistic worldview of Native American peoples, emphasizing the importance of balance, reciprocity, and harmony within the cosmic order. In this context, astronomical observations and celestial events become practical markers of time and spiritual expressions of the ongoing relationship between the physical and spiritual dimensions of existence.

2.4.3 Astronomical perspectives of Polynesians

The astronomical worldview of Polynesians is deeply intertwined with their extraordinary seafaring and navigation skills, making them masterful oceanic voyagers across the vast Pacific. Central to Polynesian navigation is the concept of wayfinding, an ancient system that relies on a profound understanding of the stars, celestial bodies, ocean currents, and bird migrations (Clark, 2020 pg75). Polynesian navigators memorise an intricate star compass, mapping the positions of stars at different times of the night and year, allowing them to determine their direction and latitude while navigating the open sea (Walker, 2012). The rising and setting of specific stars and constellations, such as the Southern Cross and the Pleiades, play a crucial role in determining the navigator's position and the direction of their vessel (Walker, 2012).

The navigational expertise of Polynesians is further demonstrated through the use of other natural cues, such as the behaviour of ocean waves, the flight patterns of migratory birds, and the colour of the sea. Traditional double-hulled canoes, like the Hawaiian outrigger canoe, were essential vessels for these maritime journeys (Noe et al., 2020). The Polynesian astronomical worldview not only facilitated practical navigation but also had profound cultural and spiritual significance. The ability to navigate across vast expanses of the Pacific Ocean, often without any visible land for days, exemplifies the remarkable fusion of astronomy, environmental awareness, and cultural knowledge that has been passed down through generations within Polynesian communities (Walker, 2012).

2.5 Looking up at the starry night, feeling awe, and gaining humility

It has been hypothesised that the rise of Western civilization is associated with a disconnection of our self-identity from the natural world. Jason Hickel attributes this to a change in our 'theory of being' that he describes as 'The Great Separation' (Hickel, 2020). Hickel argues that Europeans began to perceive themselves as distinct from nature, and this resulted in a separation between the mind and the body. Bacon and Descartes are commonly attributed to this shift, although they were perhaps only uncovering longstanding philosophical veins that extend back to Plato and even earlier. Bacon's desacralization of nature and Descartes' dualism supplanted traditional animist perspectives, which acknowledged the inherent connection of spirit with matter and viewed the entirety of nature as both intelligent and alive. Thus, a kind of 'human supremacy' is associated with capitalism, western civilization, and modern thought. As Western civilization has come to dominate the planet, so increasingly has the light that emanates from our cities at night, causing a profound change in our experience of the natural night skies and the associated thoughts of the vastness of the universe. The sense of 'awe' that we experience when looking at the Milky Way may also have a great deal to do with our sense of humility (Keltner, 2023).

2.5.1 Starry nights and the sense of awe

The observation of the stars at night has long been a source of profound wonder and awe for humanity (Consolmagno, 2009). This sense of awe, inspired by the celestial display above, is a deeply ingrained aspect of the human experience, influencing art, philosophy, and spirituality throughout history (Keltner, 2023).

One of the primary factors contributing to the awe-inspiring nature of stargazing is the sheer scale of the universe. The night sky serves as a canvas upon which countless stars, galaxies, and celestial bodies are scattered in an incomprehensible array. The enormity of the cosmos, with its billions of galaxies, each containing billions of stars, challenges the limits of human comprehension. As we look up, we are confronted with our own insignificance in the grand tapestry of the universe, fostering a humbling and awe-inducing perspective.

The stars in the night sky are the remnants of ancient cosmic events and the beginning of new celestial phenomena. Each star has a unique story; some of the light that reaches our eyes has travelled across vast cosmic distances, sometimes spanning millions or even billions of years. The realization that the light we see tonight may have originated eons ago creates a profound connection between the observer and the distant reaches of time and space (NASA,

2023). Stargazing becomes a journey through the ages, a glimpse into the cosmic past that adds an extra layer of depth to the experience.

Beyond the scientific understanding of astronomy, the observation of the stars taps into the human psyche on a spiritual and existential level (Keltner 2023). Many people throughout history and across cultures have associated the night sky with the divine, perceiving the stars as celestial deities or manifestations of higher powers. In the past and present, the night sky serves as a source of inspiration for artists, poets, and dreamers who find solace and inspiration in its timeless beauty.

In conclusion, the observation of the stars at night elicits a sense of awe that is deeply rooted in the human experience (Keltner, 2023). The sheer scale of the universe, the cosmic history encoded in the light that reaches our eyes, the rhythmic dance of celestial bodies, and the spiritual and existential dimensions all contribute to the profound impact of stargazing. As we look up into the night sky, we are reminded of our place in the cosmos, our connection to the ancient past, and the enduring mysteries that continue to captivate the human imagination (Norris & Hamacher, 2013; Shapshay, 2021; Barragan & Meltzoff, 2024).

2.5.2 Does a sense of 'Awe' inspire a sense of humility?

The profound sense of awe that envelops us when we gaze at the stars has a transformative impact on our perspective, instilling in us a profound attitude of humbleness and humility. The night sky, with its vastness and cosmic wonders, serves as a powerful reminder that our existence is fleeting within the grandness of the universe (Consolmagno, 2009).

The enormity of the cosmos, as revealed through the stars, challenges the ego-centric nature of human existence (Keltner, 2023). The countless celestial bodies scattered across the expanse of the night sky dwarf our individual lives and even the collective history of humanity. This cosmic immensity prompts a realization that our concerns, ambitions, and struggles are but fleeting moments in the vastness of time and space. In the face of the infinite, we are humbled, acknowledging the limitations of our understanding and the transience of our endeavours.

Stargazing invites us to contemplate the age of celestial bodies, each following its predetermined path with mathematical precision (Boner, 2021). The patterns of the stars and the predictable orbits of planets stand in stark contrast to the unpredictable and often chaotic nature of our existence on planet earth. This contrast fosters a sense of humility as we

recognise the order and precision inherent in the astronomical space, contrasting with the uncertainties that characterise our human experience.

The humility inspired by stargazing extends beyond our individual lives to encompass the collective human journey. The shared experience of contemplating the night sky has transcended cultures, civilizations, and epochs (Clark, 2020). It reminds us that we are a small part of humanity that goes back in time and will continue into the future. The stars serve as a timeless witness to the unfolding of human history, fostering a sense of humility as we recognise our place within this larger cosmic narrative (Barragan & Meltzoff, 2024).

Moreover, the celestial wonders prompt reflection on our relationship with the natural world. In ancient times, many cultures embraced animistic beliefs that perceived the spirit within all of nature. The desacralization of nature in more recent times, epitomised by figures like Bacon, has given way to a detached and utilitarian view of the environment. Stargazing, however, rekindles a sense of awe for the interconnectedness of all things (Keltner, 2023).

In conclusion, the awe-inspiring experience of looking at the stars generates a profound sense of humbleness and humility (Chen & Mongrain, 2020). The vastness of the cosmos, the cosmic order, the enduring journey of light, and the shared human connection to the night sky collectively contribute to this transformative perspective (Szucs-Csilik, 2021). Stargazing invites us to step outside the narrow confines of our individual lives and recognise our place within the cosmic narrative, fostering a humility that can inspire a deeper appreciation for the interconnectedness of all things.

The night skies have profoundly influenced human culture the evolution of science. The following three chapters explore attempts to look at the value of natural night skies at global, community, and individual levels. There are growing threats to our opportunity to even experience natural night skies. Understanding their value is presented as an evidence based rationale for increased efforts to protect the natural night skies.

Chapter 3 The Ecological Economics of Light Pollution: Impacts on Ecosystem Service Value

3.1 Abstract

This chapter aims to look at the impacts of light pollution at the global scale. Light pollution has detrimental impacts on wildlife, human health, and ecosystem functions and services. This paper explores the impact of light pollution on the value of ecosystem services. We use the Simplified All-sky Light pollution Ratio (sALR) as a proxy for the negative impact of light pollution and the Copernicus PROBA-V Global Landcover Database as our proxy of ecosystem service value based on previously published ecosystem service values associated with a variety of landcovers. We use the sALR value to ‘degrade’ the value of ecosystem services. This results in a 40% reduction in ecosystem service value in those areas of the world with maximum levels of light pollution. Using this methodology, the estimate of the annual loss of ecosystem service value due to light pollution is \$3.4 trillion. This represents roughly 3% of the total global value of ecosystem services and 3% of global GDP estimated at roughly \$100 Trillion in 2022. A summary of how these losses are distributed amongst the world’s countries and landcovers is also presented.

3.2 Introduction

Light pollution is increasingly recognised as a threat to human health and wellbeing in addition to constituting a growing threat to wildlife and many ecosystem functions and services. Despite these recognised problems, light pollution is increasing by 2%-10% per year (Kyba et al., 2017; Kyba et al., 2023). This is despite (and occasionally because of) new technology aimed at reducing light pollution (e.g. LEDs) (Hung et al., 2021). The natural night sky is the resource affected by light pollution. Effective stewardship of natural night skies is a challenging problem at the nexus of science, policy, communication, coalition building, monitoring, and enforcement. Night skies that are not impacted by anthropogenic light are a characteristic of functioning ecosystems. The ecosystem services provided by these functioning ecosystems are degraded by anthropogenic light (Abraham et al., 2019). There is growing recognition that light pollution represents an unrecognised challenge for ecosystem service research and management (Jägerbrand & Spoelstra, 2023; Lyytimäki, 2013; Marangoni et al., 2022).

3.2.1 Human health impacts of light pollution

Research on artificial light at night (ALAN) and the impacts of the loss of natural night-time light cycles on humans includes studies of shift work, health, well-being, and sleep (Nadybal

et al., 2020; Ritonja et al., 2020; Rybnikova et al., 2015; Ventriglio et al., 2021; Zając et al., 2021). Light pollution has significant impacts on humans. Evidence from controlled experimental studies shows that nocturnal light exposure impacts our visual system, disrupts our circadian physiology, suppresses melatonin production, and causes sleep disorders (Mason et al., 2022; Zielinska et al., 2023). There is growing evidence that nocturnal light pollution causes increased levels of chronic diseases including breast cancer, obesity, diabetes (Kraus, 2016; Muscogiuri et al., 2023). For a more complete review of human health impacts of light pollution see the following (Cho et al., 2015; Liu et al., 2023; Svehkina et al., 2020; Wang et al., 2023). Due to the minimal research to date in the area of light pollution and human health there is a strong need for incorporating more stringent protocols and research (Bozejko et al., 2023).

3.2.2 Ecological impacts of light pollution

Sanders and Gaston (2018) show light pollution causes a broad array of impacts for non-human organisms. Diurnal cycles have been a significant environmental reality for virtually all of human and non-human evolution. We are only beginning to understand the impacts of light pollution and associated problems while acknowledging that these effects on natural ecosystems are highly variable and complex (Jägerbrand & Spoelstra, 2023). Light pollution impacts vegetation (Meravi & Prajapati, 2020; Czaja & Kolton, 2022). In another study, Solano-Lamphar and Kocifaj (2018) modelled skyglow and found that some types of artificial light at night can have effects on plant photoreceptors in addition to affecting the plant phenology. In Australia, the nocturnal migration of the Bogong Moth and the alarming decline of moths migrating to the Australian Alps is a complex problem but one of the factors is light pollution (Green et al., 2021). Marine and Coastal Area effects include seabird and sea turtle hatchlings navigations, predation patterns, failure of coral spawning synchronization and even inhibition of certain zooplanktons (Marangoni et al., 2022). Our understanding of the ecological impacts of light pollution are nascent and growing. This suggests we conduct assessments of the lost value of natural night skies.

3.2.3 Light pollution as a negative impact on Ecosystem Service Value

This research explores the role that natural night skies have on ecosystem service value. The extensive number of valuation studies of ecosystem services explicitly ignore or fail to include the impacts of light pollution. The values determined in these studies may include light pollution implicitly but do not account for spatial variability in the quality and intensity of these impacts. Artificial Light at Night (ALAN) can have disruptive impacts on ecosystem function (Svehkina et al., 2020). This suggests that a natural ecosystem with no light pollution has a value of

'x/hectare' whereas light pollution would be subtracted from 'x/hectare' depending on the spatial extent and intensity. Incorporation of sensory re-sources (visual, auditory, and olfactory) as positive or negative impacts on ecosystem services is not documented clearly in existing studies.

Public understanding of the value and importance of natural night skies is often recognised at the personal level. However, the public does not perceive the aforementioned qualities of these sensory resources. We need an improved approach to communicating the importance of these sensory resources to the public. This research provides an estimate of the lost value of ecosystem services caused by light pollution.

3.3 Data and Methods

3.3.1 Data

Our baseline ecosystem service value dataset is derived from the same methodology used by Costanza et al. (2014). Here we treat light pollution in a similar manner to land degradation as an impact on the value of ecosystem services (Sutton et al., 2016). The global landcover dataset used in this particular study was obtained from the European Space Agency [<https://earth.esa.int/eogateway/catalog/proba-v-1km-333m-and-100m-products>]. The Land Cover characteristics provided 23 landcover classes at 100-meter spatial resolution. Description of the image processing and calibration of this dataset is provided by Sterckx et al. (2014). These 23 landcover classes were aggregated to broader categories based on available matching ecosystem service value categories from the previous research (Costanza et al., 2014). Some ecosystem service values associated with these landcovers were updated using an updated version of the TEEB table (Costanza et al., 2014). The ecosystem service values and aggregated landcovers are presented in Table 3.1.

Light pollution manifests in many ways. It consists of several components including glare, trespass, skyglow, clutter. Here we use a spatially explicit model of skyglow. This skyglow model serves as a proxy measure of many different combinations of the components of light pollution. We recognise that there is a difference between astronomical and ecological light pollution (Longcore & Rich, 2004). Astronomical light pollution impairs earth surface observation of the skies; whereas, ecological light pollution refers to the infiltration of point sources of light into local marine and terrestrial environments. The spatially explicit impact of artificial light at night (ALAN) was represented by the Simplified All-sky Light Pollution Ratio (sALR) (Duriscoe et al., 2018) derived from the VIIRS DNB annual composite for the year 2020 (Falchi et al., 2019). The sALR is different than the commonly used New World Atlas of artificial

night sky brightness (Falchi et al., 2016) in that it accounts for sky brightness from all directions. Simply put, this includes skyglow from the horizon at all locations. We reclassified the sALR dataset to the nine Bortle Scale levels (Bortle, 2001). We submit that light pollution impacts Ecosystem Service Value proportionally to Bortle Scale Classes and that the highest Bortle Scales (ie the brightest places with the highest levels of light pollution) will have the most degraded ecosystem service values. We use the Bortle scale to ‘degrade’ the value of ecosystem service by 5% for each of the nine levels. This results in a 40% reduction in ecosystem service value in those areas of the world with maximum levels of light pollution. We acknowledge that this approach to estimating the impact of light pollution on ecosystem service value is an oversimplification of what is undoubtedly a complex and spatially variable phenomenon. We suggest that the highest levels of light pollution are predominantly in urban areas with significant impacts on human health due to high population densities. We posit that the negative externalities of light pollution affecting human health in urban areas degrade those ecosystem services by 40%. Light pollution in exurban areas (Sutton et al., 2006) with a mix of wild-life and humans tends to have lower percentage degradations of ecosystem service value. Most of the Earth’s surface is not directly affected by light pollution (77% of Earth’s surface has a Bortle Scale of 1). The impact of light pollution we are measuring is derived solely from those areas of the Earth with a Bortle Scale above one. We acknowledge that light pollution is impacting areas of the earth that have no direct light pollution (e.g. Bogong moth migration and Bird migration) (Horton et al., 2019).

Additional data used in the analysis include the population data for each country which was extracted from the GHSL 2020 dataset using the Global Human Settlement Layer (GHSL) population density map from 2020 (Schiavina et al., 2020). The country boundaries were obtained from the World Bank (TWB, 2022).

Table 3.1. Ecosystem Service Values associated with aggregated PROBA-V Global Landcover Database categories (Costanza et al, 2014).

lcCode	Land Cover	ESV (\$/ha-yr)
0	unknown	0
20	grasslands_range	4,166
30	grasslands_range	4,166
40	cropland	5,567
50	urban	6,661
60	deserts	586
70	snow_ice	0
80	lakes_rivers	12,512
90	wetlands	140,174
100	tundra	648
111	boreal	3,137
112	tropical	5,382
113	boreal	3,137
114	boreal	3,137
115	forest	3,800
116	forest	3,800
121	boreal	3,137
122	tropical	5,382
123	boreal	3,137
124	boreal	3,137
125	forest	3,800
126	forest	3,800
200	ocean	660

3.3.2 Methods

We used an sALR of 10 to establish a threshold of maximum light pollution impact on ecosystem service value. We arrived at the value of 10 because that is the level at which the milky way disappears (Elvidge et al 2017). The disappearance of the Milky Way impacts insects (e.g. Dung Beetles), and avian species (Doren et al 2017; Witherington et al 2014). We used a reclassified version of sALR such that all values greater than 10 were set to a value of 10. We chose this threshold to represent the maximum degradation of Ecosystem Service value. The formula uses this reclassified sALR (RCsALR) in the formula as follows:

$$\text{Light Pollution Degraded ESV} = \text{BaseESV} * [0.6 + (0.4 * (1 - (\text{RCsALR}/10)))]$$

This equation preserves 60% of the Ecosystem Service value in the most light polluted are-as with a continuous linear increase in ecosystem service value reaching 100% of pristine at an sALR of 0.0. The RCsALR ranges from 0.0 for a clear night sky to 10 at light pollution levels in which the Milky Way is not discernible. This results in a 40% reduction in eco-system service value in those areas of the world with maximum levels of light pollution.

We acknowledge that this approach to estimating the impact of light pollution on ecosystem service value is an oversimplification of what is undoubtedly a complex and spatially variable phenomenon. Most of the Earth's surface is not directly affected by light pollution (over 77% of Earth's sALR less than 0.05). We acknowledge that light pollution is impacting areas of the earth that have no direct light pollution (e.g. Bogong moth migration and Bird migration). Varying levels of light pollution will have differential impacts on species, habitat, and human health. Our approach is an oversimplification of a complex and variable phenomena. We suggest that the highest levels of light pollution are predominantly in urban areas with significant impacts on human health due to high population densities. We posit that the negative externalities of light pollution affecting human health in urban areas degrade those ecosystem services by 40%. Light pollution in exurban areas with a mix of wildlife and humans tends to have lower percentage degradations of ecosystem service value. This resulted in a global grid of ESV degraded by the extent and intensity of light pollution (Figure 3.1).

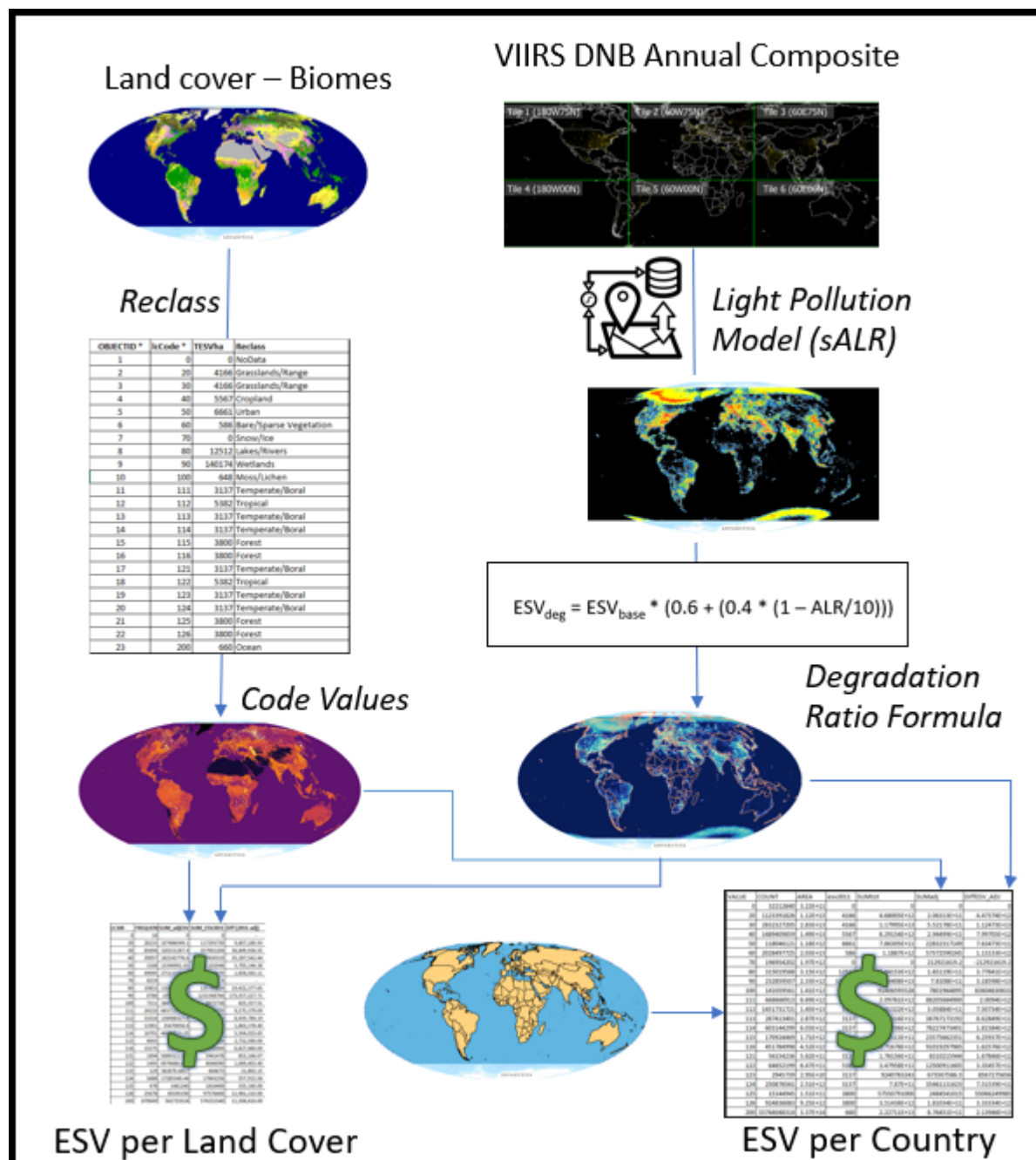


Figure 3.1. Flowchart of the processing of the Ecosystem Services value for each of the land covers and for each country. The processing includes subtracting the ESV 2011 recalculated for this landcover data set and the degraded value due to light pollution.

We selected Adelaide, an area of Australia that is home to the first National Park City in the southern hemisphere. The National Park City is a global movement of urban areas that are bringing the natural world to the residents. In addition, this area has the first Australian certified Dark Sky Reserve and one of only 15 in the world. These designations and commitment to the environment were the reasons that this area was selected as the area of interest for Figure

3.2. The Landcover, ESV, and Light Pollution degraded ESV are presented for the Adelaide and Kangaroo Island region of South Australia (Figure 3.2). The centre image shows ocean as having a relatively low ecosystem service value (\$660/ha). Skyglow from the city of Adelaide degrades those marine areas at different rates as a function of distance resulting in the lowest (darkest) ecosystem service values in the right im-age on the right. We used GIS functions to sum the original natural ESV for each landcover and for each country of the world. We then summarised the light pollution degraded ESV for each land cover and country of the world. Using these data products we determined the extent of loss of ESV from light pollution by both land cover and by country (Appendix 3.1).

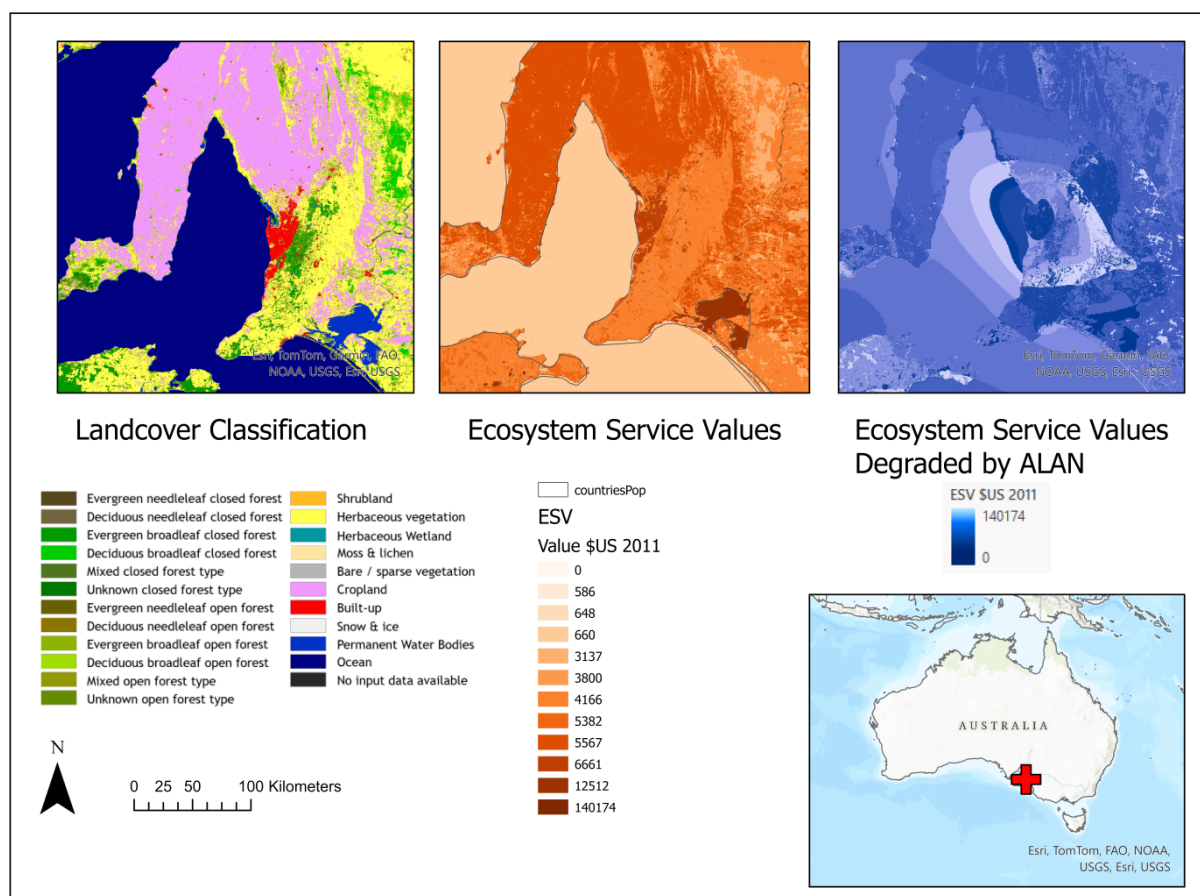


Figure 3.2. Landcover, Ecosystem Service Value (ESV), and Light Pollution Degradation of ESV for a region of South Australia centred on Adelaide.

3.4 Results and Discussion

Light pollution decreases global ESV by \$3.36 Trillion/year (Table 3). This represents 3% of the total global ESV using these landcover specific ecosystem service values with this global landcover dataset. Geographic partitioning of these impacts is thought provoking. As one

would expect, urban areas have the highest percentage losses of ESV due to light pollution at 20% (Table 3). Urban areas have the highest sALR levels because of social and economic development associated with higher population densities. The highest aggregate losses of ESV were for the following landcovers: Grasslands (\$418 B), Croplands (\$480 B), and Wetlands (\$1.3 T).

Table 3.3. ESV losses from light pollution by landcover.

Landcover	Base ES Value	LP degraded ES Value	Pcnt Loss	Total Loss
boreal	5,863,684,004,413	5,719,030,091,746	2.5	144,653,912,667
cropland	8,291,544,685,053	7,811,898,946,845	5.8	479,645,738,208
deserts	1,188,699,666,850	1,169,067,886,272	1.7	19,631,780,578
forest	5,938,223,881,000	5,728,574,756,708	3.5	209,649,124,292
grasslands	16,479,525,483,146	16,060,921,565,694	2.5	418,603,917,452
fresh water	3,941,525,085,056	3,769,933,279,928	4.4	171,591,805,128
ocean	22,271,071,887,240	21,959,997,070,930	1.4	311,074,816,310
tropical	8,161,178,257,440	8,075,040,005,861	1.1	86,138,251,579
tundra	91,406,595,528	79,563,110,775	13.0	11,843,484,753
urban	786,305,211,981	627,927,970,892	20.1	158,377,241,089
wetlands	32,640,848,534,218	31,286,886,809,109	4.1	1,353,961,725,109
Total	105,654,013,291,925	102,288,841,494,761	3.2	3,365,171,797,164

Partitioning ESV losses by country paints a different picture (Figure 3). For all of the numbers see the country table in Supplement 1. Russia (\$754 B), the United States (\$468 B), Canada (\$312 B), China (\$225 B), India (\$110 B), and Brazil (\$86 B) took the top six spots with respect total annual losses of ESV due to light pollution. The top non-island countries on a per capita basis were Canada (\$8,416 per person per year), Russia (\$5,187 per person per year), Iceland (\$3,837 per person per year), Finland (\$2,561 per person per year), and Norway (\$1,553 per person per year). Sorting this table on a percent loss of ESV ranks many island and small coastal nations at the top. These percentage losses of ESV range from 35-40 percent. The exceptions are islands and countries of extreme northern or southern latitude, for example, Svalbard data is influenced by aurora borealis lighting which is not artificial light at night.

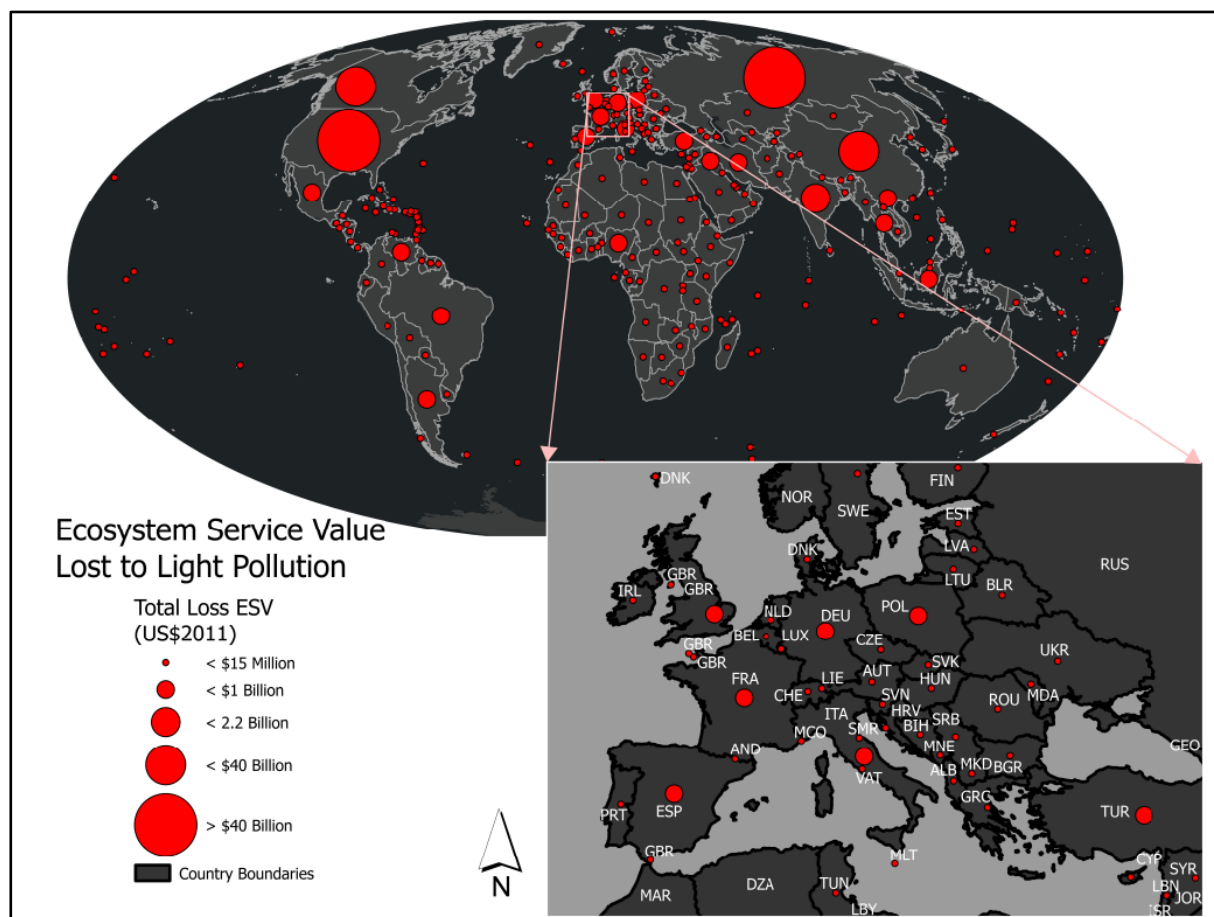


Figure 3.3. Dot map of ESV loss by country.

This work is motivated by the idea expressed by the Florida Department of Fish and Wildlife:

‘Short of a thorough discussion on the ecological place of sea turtles, it is sufficient to say that the world would be a poorer place to live without them. We just don’t know how much poorer’ (Witherington et al., 2014).

We engage in this research to raise awareness and action so that we hopefully do not have to find out. This work supports the plea for development of dark infrastructure for the preservation of biodiversity (Sordello et al., 2022) and the ecosystem service benefits of biodiversity (IPBES, 2019). Light pollution undoubtedly has a negative impact on ecosystem function and ecosystem service value. We attempt to quantify the impact of light pollution on ecosystem service value without elaborating on the myriad spatially and temporally varying ways that ecosystem functions are impacted by light pollution. This is admittedly a rough estimate of the loss of ecosystem service value. Some of these complications manifest in the spatial effects of light pollution. Areas of the world that are completely dark (e.g. experience ‘Excellent Dark

Sky') may nonetheless suffer impaired ecosystem function and reduced eco-system service value. For example, Bogong moths have migrated from winter breeding grounds throughout Queensland, New South Wales, and Western Victoria to the Victorian Alpine region for more than 7,000 years (a known ecological phenomenon). In 2017 the moth numbers crashed from roughly 4 billion to almost undetectable, and light pollution contributed to this radical disruption of the moth migration (Warrant et al., 2016). Thus, an area with 'Excellent Dark Sky' (the Victorian Alpine Region) experiences a degradation of ecosystem service value. Our model does not capture this ESV degradation. Spatial mismatch of light pollution and ecosystem service value degradation also manifests with the impacts of light pollution on sea turtle hatchling ability to reach the sea (Kamrowski et al., 2015). Our model of ecosystem service value degradation is conservative in that it associates zero degradation to the majority of the earth's surface that experiences 'Excellent Dark Sky'. The aforementioned examples demonstrate that many dark areas are nonetheless experiencing impaired ecosystem function and degraded ecosystem service value. We believe our estimates are consequently more likely to be underestimated rather than overestimates. A sketch of our rationale for ecosystem service degradation as a function of sALR values follows.

Light pollution is a driver of habitat fragmentation (Ditmer et al., 2021). Habitat fragmentation reduces biodiversity by 13 to 75 percent and impairs key ecosystems (Haddad et al., 2015). A recent experimental study (Boyes et al., 2021) showed that street lighting caused reduced caterpillar abundance by 47% in hedgerows and 33% in grass medians in urban areas. There is growing concern that we are experiencing an insect apocalypse or 'insectageddon' in which declining numbers of insects are hollowing out the bottom of the food chain. These and other studies: Declines in insect abundance (Forister et al., 2019); Insect decline in the Anthropocene: Death by a thousand cuts (Wagner et al., 2021); Toward a world that values insects (Basset & Lamarre, 2019) suggested to us that using a 40% degradation of ecosystem service value in urban areas was a plausible estimate. Recognition that even 'Excellent Dark Sky' areas often suffer from reduced ecosystem service value supports the idea that scaling ecosystem service value degradation down to 0% impact for excellent dark skies is conservative.

This research provides a method for enhancing our ability to understand the significance, spatial distribution, and magnitude of the negative consequences of light pollution. Here we estimate the dollar value of impacts of light pollution on an amalgam of complex phenomena (e.g. human health impacts, bird migration, pollination, predator-prey dynamics, foraging, etc.). Critics can argue that this approach is an over-simplification and that assessing these impacts in units of dollars is an act of hubris that serves a neo-liberal agenda of commodifying nature.

This is absolutely not the case. The global economy cannot afford to internalize the externalities of light pollution nor climate change nor loss of biodiversity, nor most of the other grand challenges associated with environmental degradation. Many degraded ecosystems and associated loss of ecosystem services are a result of anthropogenic disservices such as light pollution. Eliminating the anthropogenic disservice restores ecosystem services that provide benefits while the eliminated disservices avoid costs. This research represents a first attempt at quantifying the avoided costs and lost benefits associated with light pollution that are predominantly produced in urban environments.

3.5 Conclusion

This research was able to look at the gap in the knowledge about the value of the night skies by looking at the degradation of ecosystem services at a global scale. Examining the problem at the global scale is key to understanding the impact of light pollution which is increasing anywhere from 7-10% per year. Light pollution is increasingly recognised by the scientific community as a serious impact on human health, wildlife, and ecosystem function. This research used a skyglow model to represent light pollution with the understanding that light pollution is a combination of ALAN with skyglow as one component. This degradation of one of many sensory resources exemplifies our underestimation of the impacts of anthropogenic disservices on our natural environment. This research suggests that losses of ecosystem service value associated with light pollution are on the order of \$3.4 trillion/year. Given a global population of 8 billion we are suggesting that light pollution costs each of us more than \$375/year in lost ecosystem services. This work provides a simple scalable approach to quantifying ESV losses due to light pollution. Light pollution, unlike other types of pollution, is easily mitigated. In fact, mitigation can save money, improve health, and restore ecosystem function. Policy aimed at mitigating light pollution is a win-win-win choice in charting a path to a just, sustainable, and desirable future. Policy is needed at the global level due to the transboundary effects of light at night. In addition, policy is needed at the community level.

Chapter 4 Policy Implementation through Community Engagement

4.1 Abstract

This chapter describes the process of completing an application for an International Dark Sky Community in Australia. This represents community engaged scholarship directed toward the design, execution, and implementation of policy related to protecting the natural night skies in a particular environment. The results of this engagement were a lighting guidance policy passed by the District Council of Yankalilla December 2022 and an application for designation of Carrickalinga, South Australia as Australia's first International Dark Sky Community submitted to International Dark Sky Association (renamed to Dark Sky International in 2023 in this chapter it is referred to as IDA). This is a thesis for a school of Public Policy, and this is the public policy that was passed as part of this effort (Appendix 4.1). Community engaged scholarship rarely goes as planned. This chapter describes the circuitous route, challenges, and successes associated with both passing the aforementioned policy and completing the International Dark Sky application (See Appendix 4.2 for the full application).

4.2 The Beginning: Finding a community

Australia is a leader in understanding the importance of the natural night sky. Australia already has three International dark sky places: The River Murray, Warrumbungle Dark Sky Park, and The Jump-Up International Dark Sky Sanctuary. These are a park, sanctuary, and reserve. This effort aims at establishing the first Dark Sky Community. It is important that the community identified for this work is supportive of preserving and valuing the natural night skies. Other efforts in Australia aimed at preserving the natural night skies include Canberra. Where, because of the Mount Stromlo Observatory, a lighting policy was passed in 2012. In fact, the Australian federal government has published guidelines for lighting to protect wildlife in coastal areas (DCCEEW, 2023). This report acknowledges the growing problem of light pollution in Australia. Established in 2019, the [Australasian Dark Sky Alliance](#), a regional community that collaborates with IDA on light pollution initiatives. My colleague, Marnie Ogg, is past-president of the Australasian Dark Sky Alliance. Communication with Marnie Ogg led me to several small communities that might be interested working with me to establish Dark Sky certification.

While visiting friends in South Australia I was invited to a sausage sizzle sponsored by the Carrickalinga Ratepayers Association. My friends introduced me as an ANU PhD student studying light pollution. A waterfall of feedback ensued. The firefighter, who volunteered with the Fleurieu natural resource centre, collected data on bats in nearby Normanville. She was

very concerned about the impacts of light pollution on bats. The film director spoke about the impacts of new streetlights on his ability to sleep. The town curmudgeon told me all about his vigilante efforts to shoot out the globes of the new streetlights. The town mom talked about how there were no streetlights in lower Carrickalinga and her efforts throughout the years to keep it that way. I found my jackpot. These Carrickalinga residents embraced my research and me. These anecdotal stories encouraged to pursue Carrickalinga as my Dark Sky Community.

The next stage in the process was identifying the stakeholders.

Using the anecdotal stories from the CRA sausage sizzle I proceeded to conduct a broader assessment of community support for establishing an International Dark Sky Community at Carrickalinga. Knowing that I would be interviewing the community at large, and, coincidentally attending a course at the University of South Australia Planetarium on aboriginal night skies, I developed a survey instrument designed to measure support for the six benefits of becoming a dark sky community (Appendix 4.3). I tested a prototype of the survey with the students in the course on aboriginal night skies classroom, including several indigenous Australians. I am grateful to Paul Curnow and his students for enabling this prototype evaluation. The prototype evaluation resulted in changing some likert scales to continuous scales and language clarification. At this point, the survey instrument was ready for execution by the broader public of the District Council of Yankalilla.

I contacted the organizing committee of the Farmer's Market that would be taking place during the Festival Fleurieu in Normanville (6 March 2021) (Figure 4.1). They were happy to provide me with a free table at the Farmer's Market (next to the coffee booth). I collected 28 surveys in four hours. These surveys queried respondents regarding their values relative to each of six established benefits of becoming a dark sky community.

Table 4.1 Response Summary from Farmer Market Visitors

Benefits	Average Likert Response (where: 1 strongly disagree and 5 strongly agree)	
	Average	SD
1) Save money	4.32	1.04
2) Improve Human Health	4.32	0.8
3) Enhance Public Safety	3.64	0.85
4) Healthy Planet makes Healthy People	4.54	0.68
5) Cultural / Heritage / History Benefits	4.29	0.75
6) Tourist Economy	4.67	0.52



Figure 4.1: Photo of Fleurieu Festival booth for survey of community endorsement of Carrickalinga becoming an International Dark Sky Community.

Assessment of these surveys showed unanimous support for establishing Carrickalinga as a Dark Sky Community and reducing light pollution in the Fleurieu in general (Appendix 4.3). The only concern of the respondents manifested in issues related to public safety. Although the responses were mixed on this particular issue. This is primarily an educational problem. Current research suggests that lowering light levels at night does not compromise public safety in terms of traffic or crime (Marchant et al 2020, Morrow and Hutton 2000).

4.3 Establishing the Carrickalinga Dark Sky Committee (CDSC)

An essential component of IDA certification is identifying an established backbone institution that commits to the long-term efforts associated with policy enforcement, community education, and annual reporting. The CRA committed to serving as the backbone institution. Thus, the creation of the committee started with the CRA elected officials. Kim Baker, the president of the CRA at the time, invited me to propose the idea of having Carrickalinga become the first Dark Sky Community in Australia at the annual CRA meeting (12 Dec 2021). This resulted in establishing a formal committee to oversee the application process which

begins with passing a lighting ordinance. The committee consisted of Kim Baker, Sheryn Pitman, Amy Gephardt, and me. Having established the Carrickalinga Dark Sky Committee (CDSC) and commitment from CRA I was now able to initiate the application process with the IDA. The CRA provided the funds for the application fee.

4.4 Public Policy – the long and winding road to passing a lighting ordinance

In parallel with the establishment of the CDSC I worked to identify what would need to take place in order to pass a lighting ordinance. This involved meeting with the Yankalilla council working group and the town CEO (Nigel Morris). This meeting resulted in an informal endorsement of the goal. The Yankalilla council was willing to share data regarding existing lighting within Carrickalinga and provide contacts at South Australia Power Network (SAPN). At this point I produced a draft of lighting ordinance text in consultation with IDA, CDSC, and Nigel Morris. In addition, the CRA raised funds to retrofit the streetlights within Carrickalinga that were not compliant with the ordinance we were proposing which meets night sky friendly lighting as defined by the IDA.

Here is where the big hiccup manifested. Nigel Morris (CEO of Yankalilla) proposed a motion at the Council meeting which started with a request for \$20,000 to retrofit lights. The CRA had previously obtained a quote for much less – roughly \$3,000 for the same task. With forthcoming elections, the council was loathe to be seen as favouring one neighbourhood (Carrickalinga) over the rest of the District Council of Yankalilla with this expense. Therefore, the motion failed.

The CDSC regrouped and I presented a 'lessons learned' story to them. CRA president Kim Baker bombarded e-mails to the new council and mayor stating that the failure of the motion needed to be reviewed and revisited. With our past knowledge, we met with the new Mayor and new CEO (Nathan Cunningham), both of whom were extremely supportive and confused by the failure of the previous motion. This led to another presentation to the full Yankalilla Council and community members (20 June 2022). The councillors at the briefing session voted to reconsider the lighting ordinance motion at the next council meeting. At that council meeting the motion passed to community consultation.

4.5 Community consultation

The endorsement of the Draft Policy (original) activated the public consultation activities in line with Council's Public Consultation Policy and Community Engagement Framework. I worked with the town council and the CDSC to create an interactive website that solicited input from the community and public at large (<https://www.yoursayyankalilla.com.au/dark-sky-carrickalinga>). This community engagement platform described the benefits of becoming a dark sky community, provided a draft policy for the lighting ordinance, and solicited comments from the public. This website addressed the following frequently asked questions: What is a Dark Sky? What is light pollution? What are the problems with light pollution? What is the dark skies movement? What is smart lighting? Is smart lighting safe? Why become a dark sky community? Why Carrickalinga? How can Carrickalinga become a Dark Sky Place when so close to the lights of Adelaide? What can I do at home to reduce light pollution and contribute to the dark skies' movement? What about decorative lights and Christmas lights? Where can I find further information? Appendix 4.4 contains the text of the answers to these questions.

Results of the consultation suggest over 80% of the residents were in support of Carrickalinga becoming a Dark Sky community. Running from 29 September – 13 November 2022, careful consideration was paid to Council's Caretaker Policy prior to resolving to undertake consultation during caretaker period and a conscious decision was made to commence the consultation within that period. The Community Engagement project was simple in nature, asking the community of Carrickalinga and the broader District to provide their feedback with two main questions in mind:

- 1) How satisfied are you with the concept of Carrickalinga becoming a Dark Sky Community?
- 2) How satisfied are you with the Draft Dark Sky Lighting Policy for Carrickalinga?

The online engagement was excellent with 116 visitors to the site viewing the videos and over 70 visitors downloading both the policy document and the FAQs to have a read. The Community Engagement project was widely promoted, giving those who are interested an opportunity to get input. 182 visitors to the site contributed to the survey (+ a few others came in via email). Some additional statistics are below:

1. Over 60% of the respondents live or own property in Carrickalinga, and another 27% live or own property in the District.
2. Over 80% are 'satisfied' with the concept of Carrickalinga becoming a Dark Sky Community.

3. Over 85% of respondents are 'happy' or 'very 'happy' with the draft dark skies lighting policy.

This feedback gave the District Council of Yankalilla confidence in pursuing the initiative. The consulting firm that worked in collaboration with us to elicit public feedback made the following conclusions:

1. Dark Sky Communities demonstrate excellence in promoting responsible lighting and dark sky stewardship, serving as positive examples for other communities to reduce light pollution, energy emissions, and improve human and environmental health while saving costs.
2. For the Carrickalinga Ratepayers Association (CRA) to succeed in Carrickalinga becoming Australia's inaugural Dark Sky Community, a demonstrated commitment from the community is essential. This commitment involves preserving and protecting the night-time skies through thoughtful lighting design and the use of environmentally responsible lighting.
3. Progressing promptly has been crucial for Carrickalinga to be the first Dark Sky Community in Australia. The community remains on track, and being the pioneer provides unique promotional opportunities that subsequent communities may not have.
4. The application to the International Dark-Sky Association (IDA) must include an enacted and legally effective outdoor lighting policy. Additionally, evidence such as a letter of support from the community government (mayor, council, etc.) consenting to the IDA Dark Sky Community nomination is required. The policy itself is a critical component.
5. This report is presented in accordance with the Council's decision on August 16, 2022, to proceed with Community Engagement regarding Carrickalinga's potential as a Dark Sky Community and the Draft Dark Sky Lighting - Carrickalinga Policy.
6. Given the strong support received during the consultation process, it is recommended that the Council endorse the recommendations in this report. This endorsement acknowledges the efforts of the CRA, the Carrickalinga community, and the Council in advancing the application. The adoption of this policy confirms Council's support for the application to progress to the IDA.

4.6 Passing the lighting ordinance

With the support identified from the community consultation and the results of the survey comments on draft ordinance the CDSC, IDA, and I worked with the District Council of Yankalilla to finalise the lighting ordinance text. The lighting ordinance was presented as a motion and passed unanimously at the council meeting on 20 December 2022. Passing the lighting ordinance was an essential element to preparing a Dark Sky Community application for Carrickalinga.

4.7 The International Dark Sky (IDA) Application

There are multiple components of the IDA application. The complete application represents three years of work that constitute the essence of this chapter of the dissertation. The complete application can be found in Appendix 4.2. A brief summary of the components and process of preparation is provided here. There are eight sections and nine appendices in this application.

Section 1 is a brief introduction motivating the designation of Carrickalinga as a dark sky community. It is supported by letters from the mayor, the president of the CRA, and a nomination letter from Marnie Ogg (president of Australasia Dark Sky Association). Section 2 provides background on Carrickalinga's history and fit for IDA designation. This section includes maps, boundaries, and a brief summary of light pollution levels over time. In addition, it provides a general description of the night sky status of the town. Section 3 simply presents the lighting ordinance as passed. Section 4 describes the community outreach events which included presentations, handouts, surveys, meetings, media, and websites. Section 5 is the monthly monitoring of the night sky quality from various locations in and around the community. Section 6 describes the community support for designation. Section 7 is the current and future lighting management plan. Section 8 is the five year plan to establish full compliance with IDA requirements. This application is currently in review with the IDA.

4.8 Conclusion

In conclusion, this chapter details the comprehensive journey of policy implementation through community engagement in the pursuit of establishing Carrickalinga, South Australia, as Australia's first International Dark Sky Community. This community-engaged scholarship involved crafting a lighting guidance policy, passing it through the District Council of Yankalilla, and submitting an application to International Dark Sky Association (now Dark Sky International). Notwithstanding the challenges faced, including the need for stakeholder identification, the formation of the Carrickalinga Dark Sky Committee (CDSC), and the complex process of passing a lighting ordinance, the community's overwhelming support was evident through extensive public consultation and surveys. The culmination of these efforts resulted in the successful passage of the lighting ordinance and the submission of a thorough application to the International Dark-Sky Association, currently under review. This endeavour exemplifies the dedication of the Carrickalinga community, the Carrickalinga Ratepayers Association, and the District Council of Yankalilla in preserving the natural night skies and promoting responsible lighting practices.

This chapter documents the intricate journey of a community through collective engagement to implement a lighting guidance policy and pursue the designation of Carrickalinga, South Australia, as Australia's first International Dark Sky Community. The process and the support shows the values of natural night skies which is significant for communities which want to preserve darkness in our environment. As communities recognise and protect the inherent beauty and benefits of unpolluted night skies, they contribute to the overall health and sustainability of both human and natural ecosystems. Involved community engagement, can and does make a difference as demonstrated in passing policy for preserving the night skies in Carrickalinga. The chapter reflects on the broader significance of preserving natural night skies, considering environmental impacts, individual well-being, and the unique role of communities in fostering dark sky initiatives. The success of this community-driven effort underscores the value of grassroots engagement in shaping policies that contribute to the broader well-being of the Earth, its inhabitants, and human communities at large.

Public policies need public support from individuals in the public to succeed. The next chapter assesses individual levels of ecological literacy with respect to light pollution and measures 'connectedness to nature' before and after educational and experiential interventions related to light pollution and a stargazing activity. This exploration of individual attitudes and knowledge of both light pollution and the natural night skies suggests that there is significant public support for public policy aimed at protecting natural night skies.

Chapter 5 Protecting natural night skies by improving ecoliteracy and nature-connectedness

5.1 Abstract

This chapter address the question of individual connection with the night skies and potential increasing the awareness of its value. Light pollution is an environmental concern that impacts human health and the ecology of the natural world. As urbanization continues, the problem of light pollution is becoming more widespread and severe and will have a growing impact on our throughout the course of their lives. In response, there has been a growing interest in promoting ecological literacy as a way to grow people's understanding of the natural world. Improved ecological literacy can help young people move beyond their growing sense of despair and eco-anxiety toward empowering active participation in the co-creation of a just, sustainable, and desirable future. This paper discusses the potential of experiential interventions using night sky observations and educational videos to increase ecological literacy and awareness of light pollution amongst Generation Z participants. Drawing upon literature in the fields of ecology, astronomy, and environmental education, we tested the theory that night sky observation can provide a meaningful and engaging way to connect people with nature and improve understanding of the impacts of light pollution on the environment. We explore the potential for changing how we value natural night skies using night sky observations and educational interventions. The stargazing intervention did not show improvement in the 'Connectedness to Nature' scores however the text analysis showed positive impacts from the intervention. The video intervention had significantly improved ecological literacy scores. The impact of these interventions on participants' attitudes and behaviours towards light pollution and the natural environment is reported. We suggest that such interventions have the potential to promote a deeper understanding of the ecological implications of light pollution and to inspire positive actions toward reducing its impacts. We conclude by calling for continued efforts to promote the use of simple educational videos and nature experiences as tools for environmental education and advocacy in general.

5.2 Introduction

Generation Z (aka 'zoomers' or Gen-Z) are typically defined as people born in the late 1990s and early 2000s. This generation is experiencing mental health issues, including 'eco-anxiety', a condition of extreme worry about humans' impacts on the environment, particularly in relation to climate change, and related mental health issues in new and unprecedented ways (Boluda-

Verdú et al., 2022). As our future decision-makers, it is important that the natural environment remains relevant to young people. The ability to connect with and understand the environment is vital not only for the protection of biodiversity and ecological services but also for charting a path to an equitable, sustainable, and desirable future. Ecological literacy plays a foundational role in this aspiration.

Addressing light pollution and protecting natural night skies are relatively easy ‘baby steps’ toward addressing the broader and formidable ecological challenges we face. There is growing recognition that taking small steps toward larger, seemingly insurmountable goals is both motivating and empowering (Carr & Plevyak, 2020). Increasing our connectedness to nature not only improves our health but can also motivate environmentally friendly behaviours (Geng et al., 2015). Gary Turk pleads, *“Look up from your phones, shut down the display. Take in your surroundings, make the most of today”*. This study encourages Generation Z participants in both the United States and Australia to literally look up – to gaze at the stars and start learning about the nature and importance of dark skies. In contrast to many other pressing environmental issues, the policies and solutions for mitigating and/or eliminating light pollution are often win-win in that they help wildlife, save money, reduce our carbon footprint, make us feel better, and do not require significant sacrifice (DarkSky, 2023).

Global environmental attention and awareness are understandably often directed to pressing environmental issues such as climate change, loss of biodiversity, and deforestation. Less attention has been directed to light pollution (Davies & Smyth, 2018), most likely because it is less understood and seems trivial in comparison to many issues, yet the implications of light pollution are profound. Light pollution is the excessive or misdirected use of artificial lighting. The proliferation of artificial light sources such as streetlamps, advertising billboards, and illuminated buildings has resulted in a steady increase in the amount of light pollution throughout the world (Sanchez de Miguel et al., 2021). This has significant impacts on human health and ecosystems (Falchi et al., 2019). Light pollution disrupts the natural day-night cycle, leading to the suppression of the production of the hormone melatonin and impacting the sleep-wake cycle of humans and animals (Grubisic et al., 2019; Falcon et al., 2020). This can cause sleep disorders, fatigue, and reduced immune system function (Rajput et al., 2021). Light pollution also disrupts the migration patterns of birds and insects and can even affect plant growth and reproduction (Longcore & Rich, 2004). In addition, light pollution can have economic consequences, as it wastes energy and resources, and negatively impacts astronomical research and the visibility of stars in the night sky. Light pollution is a solvable problem. Encouraging young people to learn about the problem and its solutions may contribute towards alleviating eco-anxiety by empowering our youth to promote the adoption

of policies and behaviours that improve human health, restore ecosystem functions, and save money and energy.

Generation Z will be the most educated and globally connected generation ever, in terms of access to university education and networks (Parker & Igielnik, 2020). In Australia and the United States, members of this cohort are typically characterised as digital natives who have not known a world without smartphones. They spend much of their lives connected to a smartphone and to each other via social media. They also experience higher rates of depression and anxiety compared with any other generation (Vultaggio, 2021; Kotera et al 2022). Ironically, a common underlying cause of this depression and anxiety is concern over our environmental future (Gianfredi et al., 2024). Correlations between negative health outcomes and a lack of connection with nature have been reported in numerous studies (Kotera et al., 2020; Robinson & Breed, 2019; White et al., 2022). For example, the significant time spent on screens is thought to contribute to record numbers of eye problems, particularly myopia (Lanca & Saw, 2020). An intervention used in some countries is simply getting people outdoors. Programs such as “Fly a kite for sight” in Australia (Luke 2020) encourage people to fly kites because it forces people to look into the distance. The program was based on the National Myopia Prevention Program in Singapore that encourages outdoor activities (Singapore Government 2011). Numerous studies have also shown that both depression and anxiety can be reduced following nature experiences, which also promote a multitude of other physical and mental health benefits (Brown et al., 2014; Nguyen et al., 2023; Schebella et al., 2019 & 2020; Weber & Anderson, 2010). An intervention based on getting Generation Z participants off their screens, exploring the night sky, and building their knowledge of the importance of dark skies would seem to be a win-win initiative. Creating the optimal intervention is nonetheless a challenge.

Two attributes that are central to this inquiry are the concepts of connectedness to nature and ecological literacy. To assess ‘connectedness to nature’ we adopt the instrument and related concepts of Mayer and Fritz (2004). To assess ‘ecological literacy’, we draw on the work of Pitman and Daniels (2020). While definitions of ecological literacy, or ‘ecoliteracy’, have evolved during the past few decades, the ability to use knowledge and understanding of nature and how natural systems work underpins the concept; *‘ecological literacy involves the capacity to know and understand places as ecological systems, including how they function and connect with other systems’* (Pitman & Daniels, 2020). This relates closely to the Ecological Society of America’s explanation of ecological literacy as *‘key ecological knowledge necessary for informed decision-making, acquired through scientific inquiry and systems thinking’* (McBride et al., 2013). This important notion, promulgated by Frijtof Capra and David Orr, has

solutions and future orientation focused on the establishment of sustainable human communities and society. In this study, we are measuring ecological knowledge and understanding primarily through concepts related to the impacts of light pollution on wildlife, socio-ecological systems, and human health.

5.2.1 Why nature connectedness is important

Unlike our great grandparents, contact with nature is no longer a by-product of daily life for many people (Schebella et al., 2017). Most of the global population resides in cities which generate large-scale light pollution. Many people are sheltered from and therefore lack knowledge of the ecosystem services that make their existence possible (Sutton & Anderson, 2016). The consequence of this sheltered existence is profound. In what is an example of the shifting baseline syndrome (Soga and Gaston, 2018), slowly our night skies become lighter and along with it the accepted norm of the natural condition of the environment gradually changes. Our disconnection with nature enables many people to accept the loss of naturally dark skies without understanding the implications and the impacts of light pollution on their own health and the functioning of ecosystems (Pyle, 2002). Consequently, our attention to conservation efforts may be reduced (Schebella et al., 2020) and our overall health likely to be compromised (Maller et al., 2008).

Our need for 'connectedness to nature' has been studied through two major theories: 1) attention restoration theory (ART) developed by Stephen Kaplan (1995); and 2) Ulrich's stress reduction theory (Ulrich et al., 1991). Both of these theories are based on the biophilia hypothesis, the notion that humans possess an innate tendency to seek connections with nature (Kellert & Wilson, 2013). This psychological connection with nature has been the focus of many studies (Clayton, 2003, Mayer et al, 2009, Schultz & Tabanico, 2007, Sparks et al., 2014, Zelenski & Nisbet, 2014, Zylstra et al., 2014) and the benefits of connecting with nature have been extensively documented (Maller et al., 2009, Nisbet et al., 2020; Schebella et al., 2017; Weber & Anderson 2010). Baxter & Pelletier (2019) argue humans have a basic psychological need to feel a connection to nature in a cognitive, affective, and physical sense. This has been particularly noticeable during the Covid-19 pandemic as people have flocked to parks and outdoor spaces in record numbers (Lemmey, 2020; Venter et al., 2020). The benefits of nature connection are diverse and profound and include spiritual benefits, social and cultural benefits, psychological benefits (such as lower levels of anxiety and depression), and physiological benefits (such as lower blood pressure) (Keniger et al., 2013).

While there is not necessarily a set 'dosage' or amount of time one must spend in nature to achieve certain benefits, the variables associated with benefit attainment are becoming more clear. Research in the field of neuroscience suggests that even short periods in natural settings could decrease the risk of depression (Bratman et al., 2015). Häggström and Schmidt (2020) argue nature experiences are connected with agency, emancipation, and empowerment, and Gaut (2022) found the benefits of nature experiences were diminished if not followed by further experiences within 3-6 months. The way people experience nature may be more important than the time spent in nature. Richardson et al. (2021) found simple activities, such as actively observing nature, were important prerequisites to obtaining broader benefits. Five factors in particular were identified by Lumber et al. (2017) for their ability to increase nature connectedness: beauty, contact, emotion, compassion and meaning. The beauty of the night skies has inspired a sense of awe in people for generations. Astronomy can be taught and cultural meanings and stories about stars and planets can be shared, and can lead to enthusiasm for the need to protect dark skies.

5.2.2 Why we should be concerned about ecological literacy

Critical to the health and survival of any human society is knowledge and understanding of the natural ecological systems that underpin life. Ecological systems were described by Schneider and Kay (1994, p. 627) as '*systems of organisms interacting with each other and their environment within some spatial and temporal boundaries*' that range from large systems (as large as the Earth itself) to very much smaller systems (such as the ecosystem of bacteria in an animal's stomach). They include complex patterns of interconnected processes and are governed by the laws of thermodynamics (Schneider & Kay, 1994). Practical knowledge of ecological processes, including relationships between biotic and abiotic elements, has been an essential requirement for healthy and successful human societies of the past (Scholz, 2011), and remains an essential, if not widely recognised, requirement for current and future human societies.

The sustainability of human communities and settlements is intimately related to the sustainability of the rest of nature, including the integrity of ecosystems and their processes (Schneider & Kay, 1994). There are clear links between sustainability and the level of ecological knowledge and understanding within human communities (Capra, 2004; Colucci-Gray et al., 2006; Orr, 1992). Changes in the way human societies are organised and accommodated have led to an increasingly small proportion of people having direct contact with basic natural processes. Numerous studies and reports have highlighted the detrimental effects of these changed lifestyles, deemed by many to be a major crisis of our time (Ehrenfeld,

2009; Orr, 2011). Participation in and knowledge of the natural world are considered essential for human health and development in diverse ways (Kellert, 2012; Louv, 2005, 2012; Sobel, 2008). When human societies become disconnected from nature and natural systems, one unfortunate consequence is that ecological literacy is diminished and devalued.

The extent and consequences of impact by industrialised societies on nature have been debated for many decades (Steffen et al., 2007) and apprehension regarding a decline in connection between people and nature within Western societies has long been evident. In the mid-1970s, for example, it was claimed that *'a broad public literacy of biological and ecological concepts is at the heart of defining, reclaiming and maintaining environmental quality'* (Rubin, et al., 1974, p. 63). Interest in the concept of ecological literacy, however, has only emerged relatively recently. Orr (1992, p. 1) proposed that in order to achieve sustainability we require an *'ecologically literate and ecologically competent citizenry who not only understand global issues, but who also know how to live well in their places'*. Ecological literacy was the theme of the 93rd Annual Meeting of the Ecological Society of America (ESA) in 2008, from which the question arose, *'What should every citizen know about ecology?'* The authors speculated that while the level of ecological literacy within the population of the United States and other countries was not known, *'there is widespread concern that it is too low to enable effective social responses to current problems'* (Jordan et al., 2008, p. 495). A growing body of literature recognises the need for current societies to develop an ecologically literate citizenry as well as ecologically literate governance.

As communities live in increasingly dense and crowded urban environments, people lose sight and sound of their waterways, their native vegetation and wildlife, their food sources, and agricultural systems, and of their natural climate and energy systems. As light pollution increases with lighting becoming both more intense and extensive, visibility of the night sky reduces. When our senses lose contact with the natural world, we lose our sense of being in touch with or connected with nature. As explained so succinctly by well-known author Richard Louv (2012, p.104), *'We cannot protect something we do not love, we cannot love what we do not know, and we cannot know what we do not see. And touch. And hear.'*

Disconnection from the functions of ecological systems leads to loss of perspective on the role of humans in the health of the world we inhabit. Such functions include the requirements for light and dark cycles for feeding and breeding, for growing and sleeping, for predator-prey relationships, and for the navigational roles of the moon and stars for many nocturnal and migratory species. In terms of the health of the natural world, the benefits of ecologically literate human communities are profound.

5.2.3 Building curiosity, understanding and connection with the night sky

Historically, the night sky has held immense importance to society. Indigenous groups used stars to remind their people of significant messages, early explorers navigated by the stars, and even the astronauts on NASA's Apollo missions learned about celestial objects as a navigation tool. Today the awe inspired by the night sky still holds appeal, but there is a need to understand it has value beyond aesthetics. An improved understanding of the value of dark skies is important in the drive to protect these increasingly rare assets. Dark skies can plausibly be compared to the oceans; they are vast, expansive, and therefore easy to ignore. While many people still appreciate the beauty of the stars, our collective societal attention is often directed to terrestrial crises such as deforestation. More recently we have recognised marine crises, such as over-fishing and pollution, but it is vital that we look not only at our lands and seas but that we look up and understand the value of our dark skies.

Learning about the stars can be an intergenerational activity. Stargazing often takes place when people are camping or spending time in the great outdoors. Classic research by Burch and Wenger (1967) identifying the importance of childhood experience has been corroborated across the decades and so it is reasonable to assume 'Zoomers' who are taken out to see the stars will be more likely to accompany Gen Alpha and future generations in similar activities. Nakano (2022) report that Gen Z are seeking more rustic camping experiences, thus activities involving stargazing are likely to be appealing and it is strategic to focus on this group that represent future voters and decision-makers. The present study encouraged Gen Z students in both the United States and Australia to look up, to gaze at the stars on repeated occasions, and to learn about dark skies via a video intervention. In addition to the physical and health benefits this might achieve, we were interested to explore whether this approach could build understanding about dark skies and develop greater nature connection.

5.3 Methods

Three goals of this study were: 1) To determine if it is possible to increase ecoliteracy about dark skies by using an intervention involving watching a series of short videos on various topics related to dark skies; 2) To determine if it is possible to increase 'Connectedness to Nature' as measured by Mayer and Frantz's 2004 instrument by exposing students to three stargazing experiences; and 3) To investigate if there is a difference in these constructs between US and Australian participants.

The study used two participant cohorts, one in the United States and one in Australia. Australia was chosen because they have a national curriculum which includes mandatory education on

earth and environmental science for all students that is scaffolded across both elementary and secondary school. It was expected that as a result, Australian Gen Zers would have a moderate to strong level of ecoliteracy. In addition, Australia has initiated numerous responses at all levels of government (local, state and federal) aimed at embracing a large movement in nature play and nature connection which includes the children of Gen-Z (born in 1997 to 2012). Nature Play Australia is made up of four state-based not for profit organisations dedicated to supporting the health, wellbeing, and development of Australian children through outdoor play and learning (www.natureplay.org.au). University of South Australia (UniSA) in Australia was the location of the first participant cohort. The second participant cohort consisted of students at the University of Denver in the United States. Students at the University of Denver routinely cite Denver's proximity to environmental amenities such as hiking, skiing, and kayaking as significant reasons for choosing to attend this university and as such we expected these students would be likely to have above average scores for nature connectedness and possibly also ecoliteracy. We did not expect either cohort would have particularly high levels of ecoliteracy related specifically to dark skies. Participants were recruited from two similar, second-year geography classes at the University of South Australia and the University of Denver.

The design of this experiment assesses baseline ecoliteracy for 107 Gen Z students as it pertains to dark skies and baseline assessments of connectedness to nature. Two interventions were used to see if there are changes to objective measures of ecological literacy and self-reported measures of connectedness to nature, wellbeing, and individual value for dark skies.

We administered a ten question ecoliteracy quiz (Appendix 5.1) and Mayer and Frantz's 'Connectedness to Nature' instrument (Appendix 5.1) to all participants before and after one or both interventions. The two interventions were: 1) watching six short videos describing some element of light pollution (Appendix 5.2); and 2) having students engage in three successive stargazing activities in which they were provided with a star chart and tasked with identifying three celestial items (e.g., a constellation, the Milky Way, the international space station) and describing how the experience made them feel (Appendix 5.3). These are summarised in Appendix 5.5. Of the 107 participants 28 were from Australia and 79 were from the United States. A total of 75 students experienced the video intervention while 32 did not. The stargazing intervention had the same split in that 75 students participated in the stargazing activity and 32 did not. A total of 46 participants experienced both the stargazing activity and the videos while 61 students only experienced one of the interventions.

5.4 Results

5.4.1 Baseline measures of ecoliteracy

Baseline measures of ecoliteracy derived from the ecoliteracy quiz (Appendix 5.1) related to natural night skies and light pollution showed no significant difference between U.S. and Australian students. Average scores (out of 10 possible) were 5.33 for Australian students and 5.03 for U.S. students (Figure 5.1). The questions on this instrument had five possible answers for each question suggesting that if the questions were answered randomly the average score would be 2. These results suggest the participants made a good faith effort on the quiz and the fact that the scores were significantly higher than 2 suggests that the participants had some level of knowledge about natural dark skies and the impacts of light pollution.

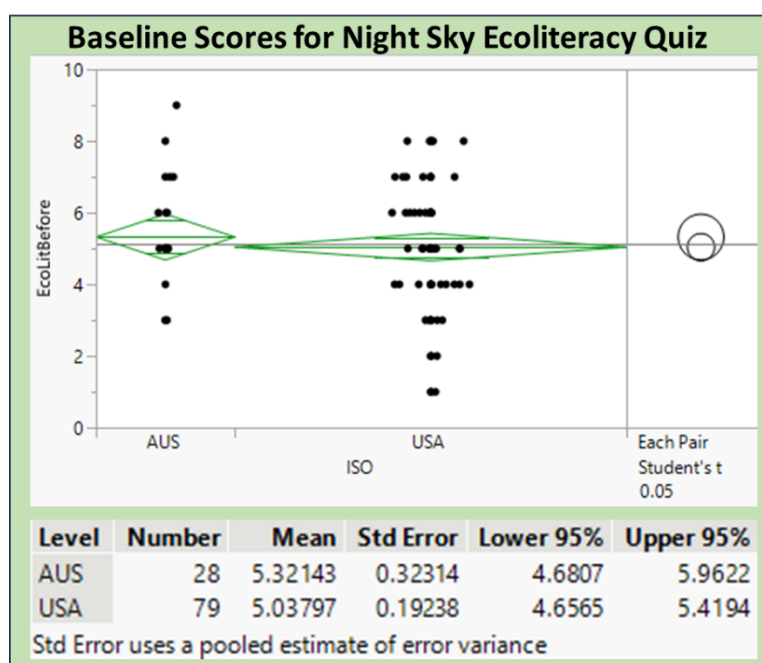


Figure 5.1. Baseline scores for Night Sky Ecoliteracy Quiz

5.4.2 Baseline measures of 'Connectedness to Nature'

The 'Connectedness to Nature' scores were derived from the Connectedness to Nature Scale (CNS) instrument (Appendix 5.2). The scores of our participants can be compared to well-established averages derived from many previous studies that have demonstrated that the CNS has good psychometric properties that predict both ecological behaviour and subjective well-being (Mayer and Frantz, 2004). The average reported score on the CNS is 3.65 derived from a survey of 60 American adults aged 18-68 with a higher than average level of education and a roughly equal split of men and women (31 male and 29 female)

(<https://www.psytoolkit.org/survey-library/connectedness-nature.html>). Our results suggest that the Australian participants have scores that are not significantly different from the established means on the CNS (Australian mean of 3.73 with 95% C.I. ranging from 3.59 to 3.88). The Australian participants are significantly different from the US participants in that they are more connected to nature. In contrast, the participants from the U.S. (students at the University of Denver) had CNS scores that were statistically significantly lower than reported averages. The U.S. participants mean score was 3.28 with a 95% C.I. ranging from 3.21 to 3.37 (Figure 5.2). The 3.65 mean CNS score we are comparing to is based on American participants with a wider range of ages raising the question - Is this difference explained by the younger age of our U.S. participants or by the nature of students that attend the University of Denver, or has the average diminished over the past two decades? The Australian participants were of the same age as the U.S. participants suggesting that the nature of the University of Denver students is the more likely explanation for the lower than average score on the CNS instrument. It has been established that University of Denver students are whiter and wealthier than the average American.

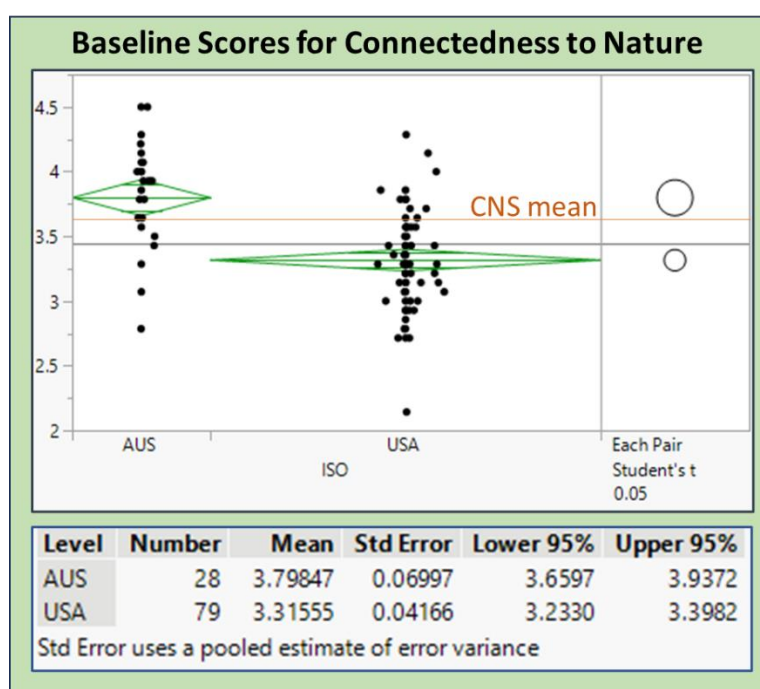


Figure 5.2. Baseline scores for 'Connectedness to Nature'

5.4.3 Effects of video intervention on Ecoliteracy Score and ‘Connectedness to Nature’

Students who experienced the video intervention (Appendix 5.3) watched six videos exploring the nature and consequences of artificial light at night. These 29 participants experienced the video intervention only (they did not undertake the stargazing activity). The mean difference score for all 29 participants was 1.5 with a 95% C.I. ranging from 0.83 to 2.16 which indicates a statistically significant improvement on the ecoliteracy quiz. Contrasting the improvement of the Australian participants (N=3) and U.S. participants (N=26) is problematic due to the small sample size of Australians (Figure 5.3). Nonetheless, both groups improved and there was no statistically significant difference in the effect (Australian mean difference of 2.33 with 95% C.I. ranging from 0.44 to 4.23 and U.S. mean difference of 1.46 with a 95% C.I. ranging from 0.82 to 2.11). The effect of the video intervention on participants scores on the CNS instrument was not significant. The mean difference between the CNS score after watching the videos and the CNS score before watching the videos was 0.18 with a 95% C.I. ranging from -0.13 to +0.02 (Figure 5.4). This suggests that watching the videos had no impact on participants CNS score.

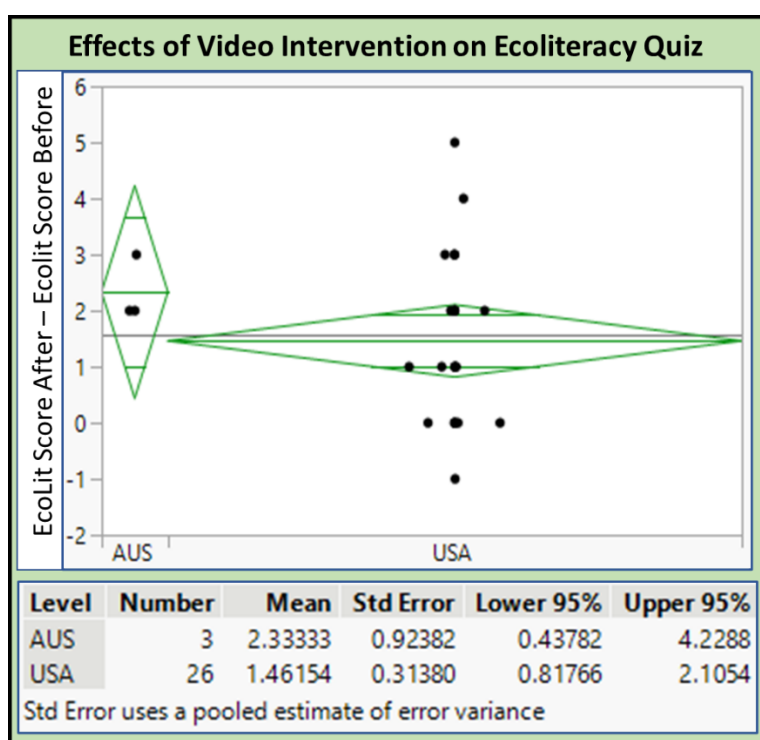


Figure 5.3. Effects of video intervention on Ecoliteracy Quiz Score

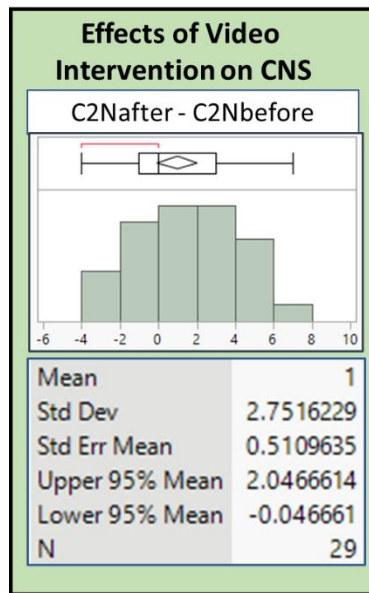


Figure 5.4. Effects of video intervention on 'Connectedness to Nature'

5.4.4 Effects of stargazing intervention on Ecoliteracy Score and 'Connectedness to Nature'

Students who experienced the stargazing activity (Appendix 5.4) went outside at night on three occasions and observed several celestial objects and provided comments about their experience. These 29 participants experienced the Stargazing intervention only (they did not watch the videos on natural night skies). The case consisted of 28 U.S. participants and only 1 Australian participant. Consequently, we did not compare U.S. and Australian means for this case. The mean difference score for all 29 participants was 0.35 with a suggesting there is no statistically significant improvement on the ecoliteracy quiz resulting from the stargazing activity (Figure 5.5). The stargazing activity was hypothesised to have some positive effect on participant's 'Connectedness to Nature'. In fact, we did see a small statistically significant impact in that the 'After' scores were slightly higher than the 'Before' scores. The mean difference between the 'After' and 'Before' score for the 29 participants who only experienced the stargazing intervention was 2.86 with a 95% C.I. ranging from 1.12 to 4.61 which does not include zero suggesting a significant difference (Figure 5.6).

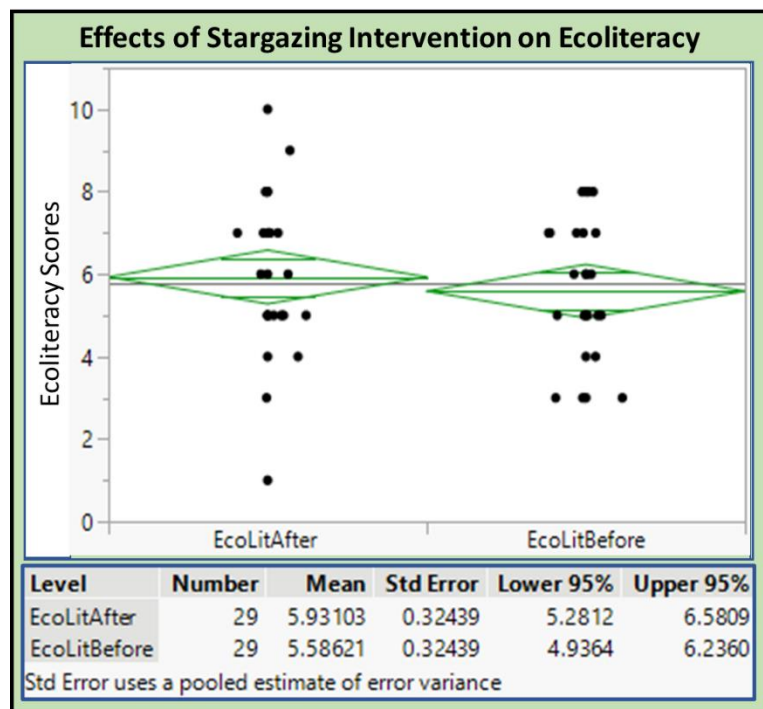


Figure 5.5. Effects of Stargazing Intervention on Ecoliteracy

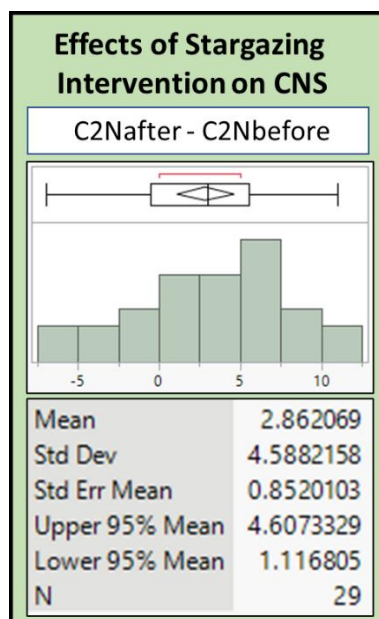


Figure 5.6. Effects of Stargazing Intervention on 'Connectedness to Nature'

5.4.5 Combined Effects of Video and Stargazing Intervention on Ecoliteracy Score

There were 46 participants (24 from Australia and 22 from the U.S.) that experienced both the video intervention and the stargazing experience. Both the Australian and the U.S. participants had significant increases on their ecoliteracy score after watching the videos and doing the stargazing exercise. There was no significant difference between the Australian and U.S. participants with respect to the size of improvements. The Australian ecoliteracy scores

improved by an average of 1.87 points with a 95% C.I. ranging from 1.10 to 2.65. The ecoliteracy scores of the American participants increased on average by 1.77 points with a 95% C.I. ranging from 0.96 to 2.58 (Figure 5.7). Average baseline scores were roughly 5 out of 10 prior to the interventions. These scores improve to roughly 6.8 out of 10 suggesting that the interventions did have a positive impact on the ecoliteracy score. While we would like to believe that the stargazing activity would result in a higher CNS score we believe that the effect is small and not statistically significant. However, the written comments provided by the participants as part of the stargazing exercise do suggest that the activity may trigger some significant change in perception that may not be captured by the CNS instrument.

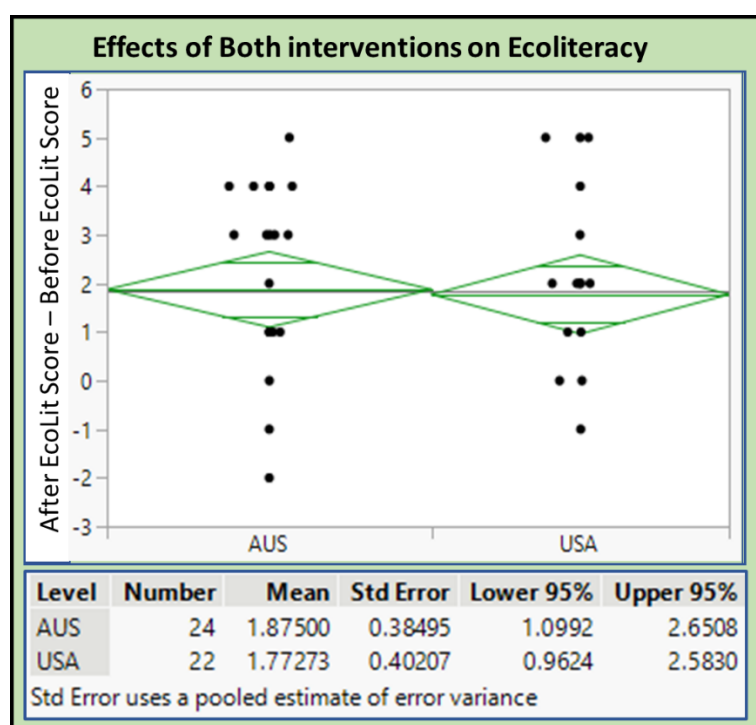


Figure 5.7. Effects of Both Interventions on Ecoliteracy

A total of 63 different celestial objects were noted by participants. As seen in Figure 9 some of these were very generic, such as “moon” and ‘stars” and others were noted as key points of navigation, for example the “Southern Cross” or Crux in the Southern Hemisphere and Polaris or the North star in the USA. Other participants were able to list technical names of celestial bodies but we were unable to determine if that was the result of using specific apps or if it represented greater knowledge of the night sky. What was clear, was the Australian cohort on average noted more celestial objects (Mean=5.16) than their US counterparts (Mean=1.85). The US cohort on the other hand, were more likely to comment about light pollution and how this negatively impacted their experience.

5.4.6 Combined Effects of Video and Stargazing Intervention on Connectedness to Nature Score

The effect of both interventions on the CNS score was essentially no change. The CNS scores of the Australian participants did not change (although the mean difference was slightly negative) while the mean difference score for the U.S. participants was slightly positive but not significantly different than zero (Figure 5.8). The slight difference in effect may be attributable to the fact that Australian participants started with higher CNS scores (3.7 vs. 3.2). In any case it appears that the impact of the video and stargazing interventions did not have any impact on the Connectedness to Nature score of either the U.S. or Australian participants. These results were somewhat different than the results for those participants that only experienced the stargazing activity. Those participants realised a slight statistically significant increase in their CNS score while those who experienced both the stargazing activity and the video intervention did not show any improvement in score. This raised the question as to whether or not there was significant interaction between the two interventions or the nationality of the participants. We ran several simple ordinary least squares regressions with the following sole dependent variable: pre-ecoliteracy score, post-ecoliteracy score, pre-CNS score, post-CNS score, and the differences between pre and post. We used the following dummy coded independent variables: Video (1 or 0), Stargazing (1 or 0) and Nationality (AUS or US) with all possible two-way interactions. The only variable that showed any statistical significance for predicting any of the dependent variables was the Video intervention.

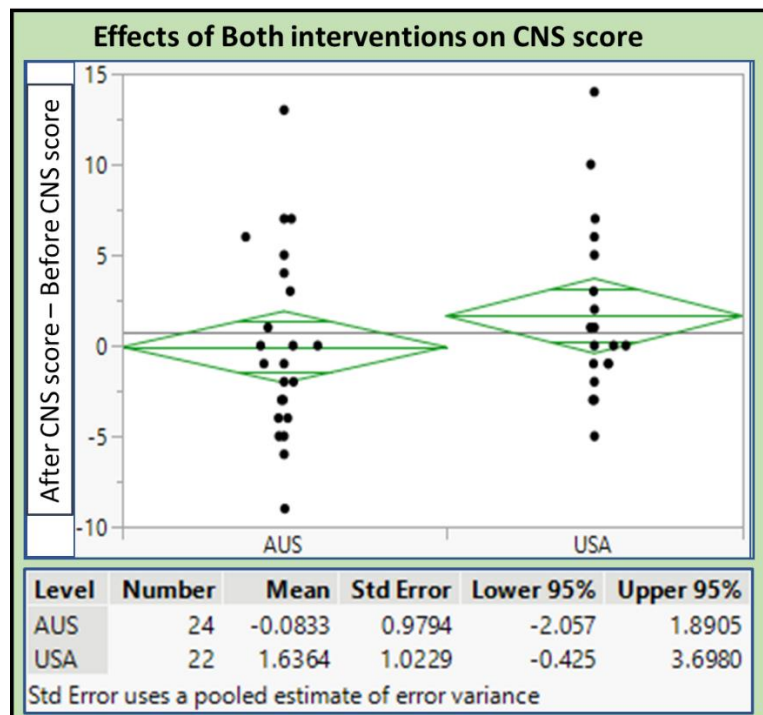
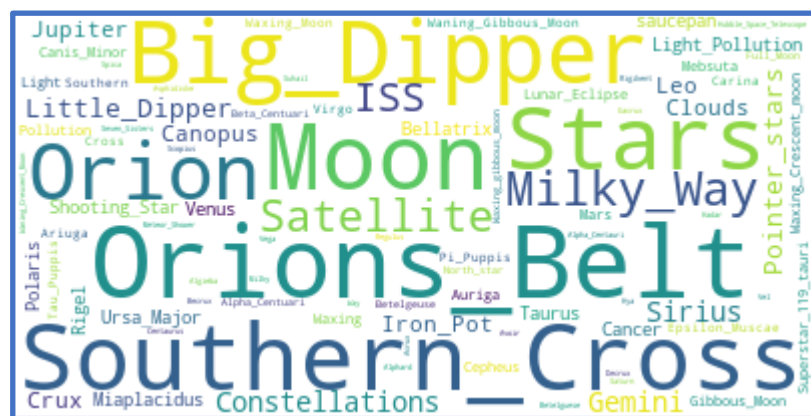


Figure 5.8. Effects of Both Interventions on 'Connectedness to Nature'

We used Microsoft Forms to collect student responses to the Stargazing activity and the 'Connectedness to Nature' survey. We produced two 'Wordclouds' to summarise the words student most frequently used for the prompts: "What did you see? List the celestial object that you observed? (constellations, the space shuttle, etc)." (Figure 5.9) and "Please describe in as many details as you can how finding the celestial objects made you feel?" (Figure 5.10). In addition, we asked students about their experience of stargazing prior to this activity and if stargazing would become a regular habit for them (Figure 5.11). The forms instrument also had an optional response with the prompt: "Please add any comments that you would like to share with the researcher". The following are a selection of these comments that capture the most common themes of response.



63

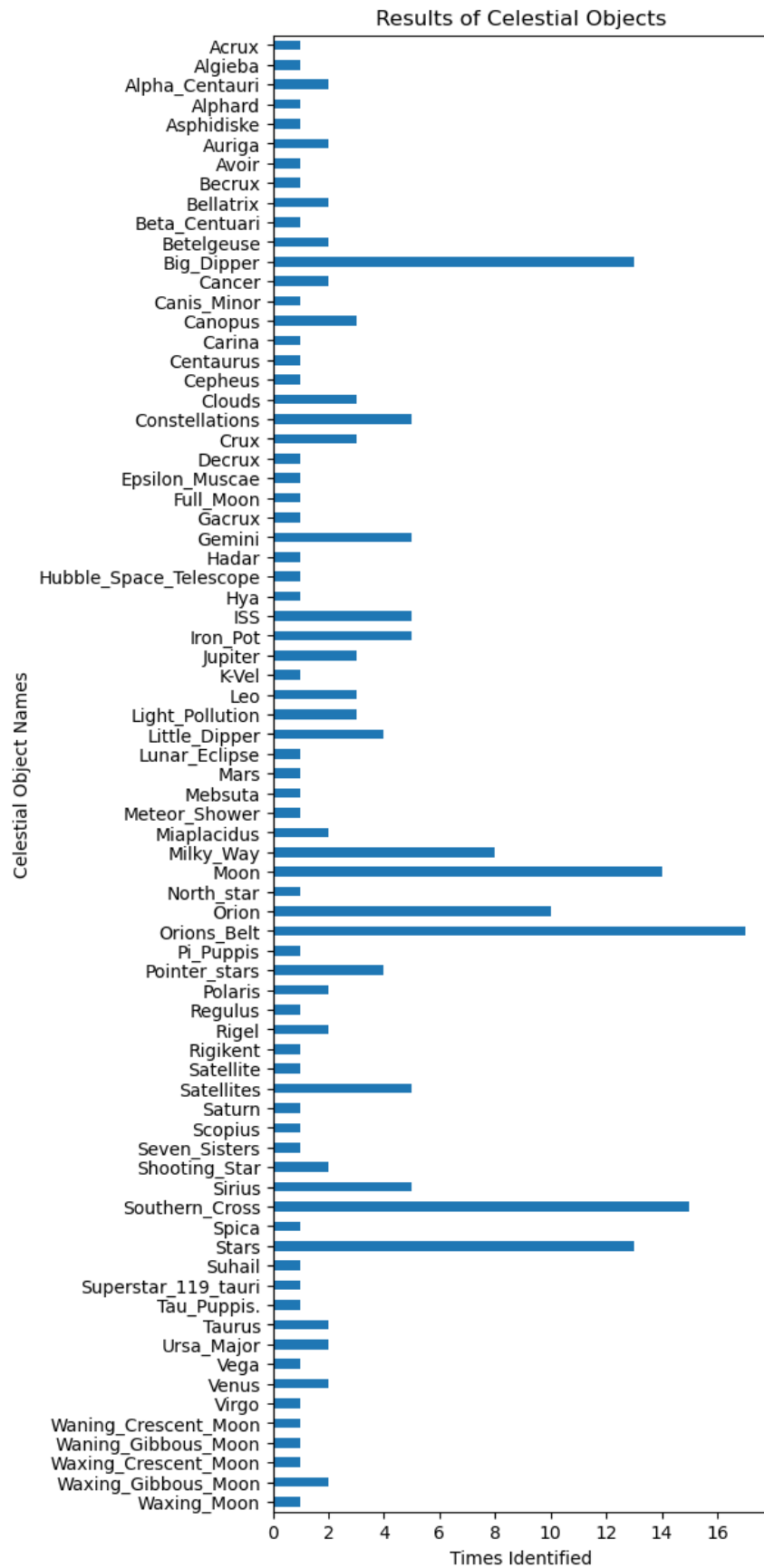


Figure 5.10. Frequency graph derived from the prompt: “What did you see? List the celestial object that you observed? (constellations, the space shuttle, etc).



Figure 5.11. Wordcloud derived from the prompt: “Please describe in many details as you can how finding the celestial objects made you feel?”

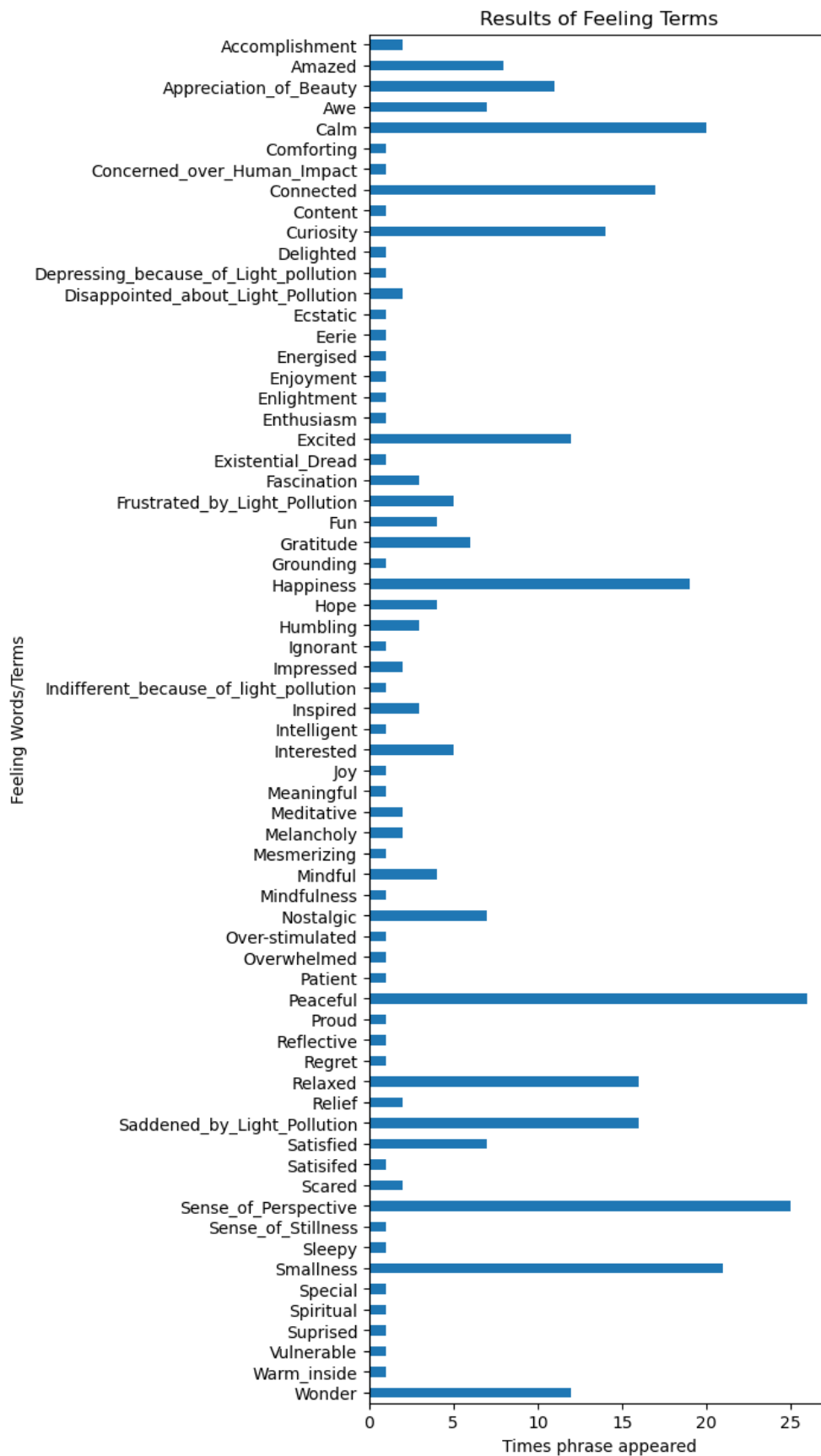


Figure 5.12. Frequency graph derived from the prompt: “Please describe in many details as you can how finding the celestial objects made you feel?”

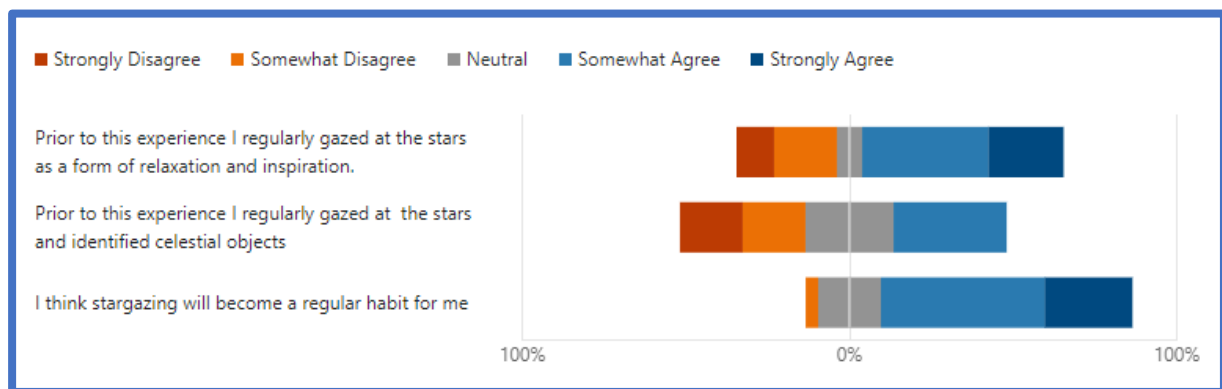


Figure 5.13. Responses to questions about prior and future experiences of stargazing.

What is clear from examining the comments is that overall participants' associated the experience of stargazing with very positive feelings. The content about feelings was analysed using an iterative "code as you go" process, where any differences between the two coders were identified and discussed. Overall, there were 323 comments about specific feelings identified, comprising 90% positive feelings, 8% negative and 2% were classified as neutral. More specifically, 28% of feelings related to happiness, joy, wonder, awe, amazement, fun, excitement, enthusiasm, fascination, delight, and curiosity. Almost another quarter (22%) of comments related to a feeling of calm, relaxation, mindfulness, or peacefulness. A further 14% of comments related to the experience giving them a sense of perspective or a feeling of being very small in the overall scheme of things. As shown in some of the comments below, this was perceived as a very positive outcome. As a generation known to be greatly affected by mental health, it was encouraging to see how many people from both countries noted the sense of peace or calm, or perspective that the skygazing experience provided.

The many comments about curiosity did suggest an interest in building ecoliteracy and they often suggested an intention to continue more regular stargazing, which may result in higher nature-connectedness over time.

The more I looked at the sky the more questions I had, and it was very satisfying to work out the answers (Australian participant)

My cousin had many questions about what each constellation meant so we googled them when we got home the next day and used the telescope to try applying the

knowledge we learnt. Each family member chimed in on things they knew when camping it was quite special (Australian participant)

.. even a little bit of time enjoying the beauty of space resulted in me feeling much less anxious and much more grounded. I used to star gaze much more frequently when I was younger, and this experience reminded me of why I love it! ...nighttime has quite a meditative effect on my disposition. (USA participant).

While looking up we both saw a glimpse of a shooting star and for me that was the first time I've seen one before so it made me feel quite enthusiastic because I never thought I would ever see one. From there we discussed how fast that would have been travelling and wondering if anyone else would have been looking up at the same time we were....From there we laid in silence for a while and reflected on our thoughts (Australian participant)

At peace, assured of my place in the world. Knowing a galaxy is out there makes lifes triumphs and pitfalls seem so trivial. Its nice. I also find my mind wandering towards thoughts of community, and society and philosophy..... Perhaps it has made me more inclined to want to understand the world. (Australian participant)

While some comments were simple and direct,

I looooooove stars (USA participant)

Other comments provided more insight into the calmness and mental health improvements that they associated with the experience:

I felt really calm, like all of my anxiety cleared. (USA participant)

It made me feel relieved to be out in the dark looking at something other than a screen (Australian participant)

Seeing the stars when they are bright is the best feeling. Your mind is able to drift off and it feel like every problem in your life is microscopic. (USA participant)

And lying there, with all these thoughts rushing through my head comes nothing but a deep silence, which is something that doesn't come often at all, and is something that is hard to reach or achieve. This is something that I feel I can only achieve through stargazing in general (Australian participant)

Many commented on the relaxing nature of the activity, often linking it to improved mindfulness.

It gave me a chance to take a break from life and observe the beautiful night sky which was very relaxing (USA participant)

I grew up stargazing and it is such a helpful relaxing activity (USA participant)

I think stargazing is a perfect opportunity for me to be more mindful and meditate in the ways that I have been really needing it. (USA participant)

There were also a suite of comments that related to a sense of connection and feeling of smallness.

Finding the celestial objects made me feel in tune with the environment and more connected to the natural world.

I had forgotten how much I love night sky viewing. Not the "Five minutes out the back" but a dedicated half an hour of stargazing. Thank you for the survey and the reconnection (Australian participant).

I felt very content looking up at the stars that night. I was very relaxed with my focus purely on the stars somewhat in a meditative state. I felt connected to the land in that moment... This feeling of being small also made my problems feel small, i felt present and in awe. (Australian participant)

Finding the celestial objects reminded me of how much infinite mystery surrounds us. When we go inside for the night we are missing out on our connection to the broader cosmos... I feel sad that I don't look at the stars all that much and I wonder how spending every night under the stars made my distant ancestors feel. (Australian participant)

The activity also appeared to promote a sense of perspective.

It made me feel small. It made me feel like nothing matters and that I am just a tiny speck in the universe. But it was kind of comforting. (USA participant)

Looking at stars makes me feel small/humbled in a good way but I could hardly see any so it made me feel a bit sad (USA participant)

There was a sense of nostalgia amongst many students who remembered seeing more stars in their childhoods, often in rural environments.

I felt sad because I realized how much light pollution there is here where I live in Denver compared to back home where it is more rural. Still I felt connected to nature if only for a moment in an urban environment. (USA participant)

Back home, I can see the night sky much clearer... Honestly, it was more disheartening than anything since I expected to see more stars. It is calming to look at the night sky, but less so when there isn't much to see. I felt less connected to nature than I had in the past, since I was not seeing what I had expected to see. (USA participant)

When I looked up, it actually made me gasp at the absolute beauty of it. Compared to what I have been getting used to seeing in Adelaide, there were so many millions of stars visible to see, and they were so much clearer as well, which I've really missed. It

made me feel as though I was in another world, and all there was, were the skies and I, along with a huge sense of peacefulness. (Australian participant)

Made me think about a camping trip I went on near Buena Vista where we were able to see many stars in the sky along with the milky way. It's unfortunate and heartbreaking we can't see that here. (USA participant)

In addition, there was a sense of sadness and melancholy expressed by many participants in relation to light pollution, such as:

The light pollution in Denver is so depressing. My friends and I fondly refer to the reddish yellow haze that the lights in the DU neighborhood create as the "yellow orb". Reflecting upon this, it's a way to acknowledge the problem and bring awareness to the issue through a semi-humorous way (USA participant).

I was also feeling annoyed and sad due to light pollution's effects on the night sky (Australian participant)

Seeing very little of the stars (as I did every night) was very saddening because being in a light polluted city, and knowing how the night should look just means we need to do better as a population. (USA participant)

It felt anti-climatic because I expected to see more stars. One streetlight made it significantly harder to make out stars. No clouds but also no stars. (USA participant)

5.5 Discussion and Conclusion

While Australia and the United States share many attributes as wealthy developed western nations, there are some different geographies, cultural practices, and policies with respect to issues related to this study. Sheer population differences make it much easier for Australians to experience nature (e.g. Southern California has a larger population than the entire Australian continent and yet Denver and Adelaide are of similar size). While both Australia and the U.S. have environmentally focused NGOs, Australia arguably has more large NGOs (e.g. Landcare Australia, NaturePlay Australia, and Orienteering Australia) that are focused on individual activities that deliberately connect people with the natural world. In contrast, large environmentally oriented NGOs in the United States are often more focused more on advocacy, policy, and fundraising (e.g. Sierra Club, The Nature Conservancy, Environmental Defence Fund). Australia has a national curriculum for earth and environmental science which spans both elementary and secondary school and involves significant field activities that are likely to build nature connection which is non-existent in the United States. These differences may explain why Australian Gen Zs have significantly higher 'Connectedness to Nature'

scores. There were no other significant differences between the Australian and American participants in this study.

While we tested for change in the participants CNS scores due to the stargazing activity we did not find that to be the case. However, the qualitative responses suggest that many of the participants did feel positively impacted by the experience. Given the limited temporal nature of this study we cannot be sure if these comments reflect a significant long-term change in attitudes and behaviours. Nonetheless, it has been demonstrated that brief experiences of the natural world can have significant health benefits.

We are not surprised that the digital intervention (watching the six videos on light pollution) had a statistically significant impact on participant scores on the ecoliteracy quiz. This is yet another demonstration that environmental education can improve ecoliteracy (Syah et al., , 2021). We hope to conduct future research that demonstrates that these short educational interventions have long term impacts on attitudes and behaviours.

We conducted this study in the spirit of developing methods to motivate and empower future generations to move beyond denial and despair and into solutions to our formidable environmental challenges. Protecting the natural night skies involves practical and manageable small steps that simultaneously improve human health, restore ecosystem function, save money, and reduce our carbon footprint. Win-win-win opportunities provide optimism that progress can be made on the larger issues of climate change and biodiversity loss. An added benefit is that the participates may engaging in these kinds of behaviours and facilitate reconnection with the natural world in ways that alleviate eco-anxiety, mitigate nature deficit disorder, and generally improve the mental health and resilience of all people.

Chapter 6 Conclusion

6.1 Abstract

Throughout the thesis I researched and explored the value of dark natural skies. It is important to note that night lighting offers significant benefits to humans, such as nighttime activities, greater productivity and enhancing the aesthetic appeal of spaces. However, there is a clear need to balance these anthropogenic advantages with the need to protect natural ecosystems and human health, proper lighting design is crucial. This involves using lighting that is appropriately directed, dimmed, use of lighting controls and of the right colour temperature to minimize light pollution, which disrupts wildlife, obscures the night sky, and affects human circadian rhythms. With thoughtful lighting design we can ensure we provide the necessary illumination for humans while preserving the natural night environment.

This thesis is premised on the idea that natural dark skies have a significant albeit mostly unrecognised value that is threatened by increasing levels of light pollution throughout the world mainly due to improper lighting design. I examine the value of natural night skies and the impacts of light pollution at the individual, community, and global scale. By measuring and acknowledging the economic and non-economic value of dark skies at global, community, and individual scales, I explore the multifaceted impacts of light pollution.

I have presented a summary of the process of establishing a lighting ordinance in a local community. In addition, I draw insights derived from experimental interventions and educational strategies. These experiences focused on Generation Z, the generation that will be most affected by light pollution in the future. I present a compelling case for the role of public policy in nurturing ecological literacy, combating eco-anxiety, and steering society towards a just, sustainable, and desirable future.

6.2 Background Summary of Research Questions

I took a multi-scale approach to understanding the bio-physical nature and impacts of light pollution on the value of natural night skies. The scales at which my investigations took place were that of individual people, a small community in Australia (Carrickalinga), and a global assessment of impacts of light pollution on ecosystem service value. I will summarise these findings from the individual level to the global scale.

6.3 Main Findings: Individual Scale

Chapter 5 describes how I answered the research question:

What impacts does a natural night skies educational intervention have on individual measures of ecoliteracy and 'connectedness to nature'?

This involved measuring the ecological literacy of individuals with respect to the impacts of light pollution on human health and ecosystem function. In addition, I measured 'connectedness to nature' before and after experiential interventions related to stargazing. It is important to understand the levels of awareness and impact of interventions on individuals when seeking to craft public policy. Drawing upon literature in the fields of ecology, astronomy, and environmental education, I tested the theory that night sky observation can provide a meaningful and engaging way to connect people with nature and improve understanding of the impacts of light pollution on the environment. The impact of these interventions on participants' attitudes and behaviours towards light pollution and the natural environment was mixed. The interventions impacted ecoliteracy scores more than connectedness to nature scores. This is likely due to the fact that a connection to nature is developed over longer periods of time.

These interventions have the potential to promote a deeper understanding of the ecological implications of light pollution and to inspire positive actions toward reducing its impacts. I call for continued efforts to promote the use of simple educational videos and nature experiences as tools for environmental education and advocacy in general. The cultivation of ecological literacy among younger generations stands as a catalyst for change in the context of light pollution. By empowering Generation Z with the knowledge, experiences, and understanding needed to appreciate the ecological significance of natural night skies, I lay the foundation for a future that is not only environmentally conscious but also deeply connected to the beauty and resilience of the natural world. This educational journey transcends the mitigation of a singular environmental threat; it forges a path toward a more harmonious relationship between humanity and the ecosystems that define our shared planet.

Understandings obtained via interactions with individuals during this research clarified that most of the subjects do value natural nights skies and experience a sense of awe that can stimulate humility and motivate actions for change. Changing the course of light pollution is a matter of public policy that necessarily manifests at the community scale.

6.4 Main Findings Community Scale

Chapter 4 describes how I answered the research question(s):

What arguments have the most traction for garnering public support for the establishment of a dark sky community?

What are the steps needed to implement lighting policy at the local government level that supports the application to the IDA for an International Dark Sky Community?

This work involved identifying a community that was amenable to protecting their natural night sky and becoming an IDA dark sky community. Carrickalinga, South Australia met these criteria. I engaged with the public in several venues including a farmer's market (with paper survey of local citizens), presentations at District council meetings, Community Centres, and on-line. I identified a backbone organization (The Carrickalinga Ratepayers Association) and formed a committee committed to completing an IDA application. The cornerstone of all IDA certified Dark Sky community applications is a lighting ordinance or policy. The survey results showed strong public support for Carrickalinga as a Dark Sky community with the reasons for support being variable. The District Council and the CRA and residents strongly agreed that preserving the night sky saves money by reducing energy costs. The residents were supportive of reduced street lighting to improve human health by reducing insomnia and sleep disorders. The only mixed results were in the area of enhancing public safety. All community members recognised that light pollution has negative impacts on wildlife. The Australian flag has the Southern Cross on it. Indigenous Australians incorporated night sky phenomena into their culture, heritage, and navigation. Hence there was strong support for natural night skies related to supporting cultural and historical benefits. The adjacent town of Normanville had many business owners that were optimistic that IDA Dark Sky Community designation for Carrickalinga would improve off-season tourist economy via astro tourism. I was instrumental in getting the lighting ordinance passed and have submitted an IDA Dark Sky Community application for Carrickalinga. Community support for policy to prevent light pollution has economic and non-economic benefits that are recognised by individuals within the community and its local environs. A missing element of the impact of light pollution is a global assessment.

6.5 Main Findings Global Scale

Chapter 3 describes how I answered the research question:

How can you frame natural night skies as an attribute of the ecosystem that can inform the valuation of ecosystem services?

Illuminating the idea that natural night skies have value is a guiding theme of this thesis. Natural night skies are an attribute of ecosystems throughout the world. Many of these ecosystems are negatively impacted by light pollution. I chose to use global assessments of ecosystem service value as a baseline from which light pollution impacts are subtracted. Light pollution as a negative impact on ecosystem service value will degrade the global value of ecosystem services. I used the All sky Light pollution Ratio (ALR) dataset to globally map ecosystem degradation from light pollution (skyglow). Maximum light pollution levels result in 40% degradation of ecosystem service. Note that 77% of the earth's surface is not impacted by light pollution; however, 80% of the world's human population is impacted by light pollution. A global map of ecosystem service value was juxtaposed with this light pollution degradation map to calculate the impact of light pollution on ecosystem service value globally. Using this methodology, the estimate of the annual loss of ecosystem service value due to light pollution was \$3.4 trillion. This represents roughly 3% of the total global value of ecosystem services.

6.6 Future Research

As society grapples with the escalating challenges posed by light pollution, the imperative for future research becomes increasingly evident. While considerable strides have been made in understanding the ecological, health, and societal impacts of excessive artificial lighting, there remain critical gaps in knowledge that necessitate focused and innovative research efforts. The following outlines key areas where future research can significantly contribute to advancing our understanding and mitigating the effects of light pollution.

6.6.1 Quantifying Light Pollution Levels

Future research should aim to refine and expand methods for accurately measuring and quantifying light pollution levels across diverse urban, suburban, and rural landscapes. Developing standardised metrics and employing advanced technologies, such as satellite imagery and ground-based measurements, can enhance precision in assessing the extent, spectral characteristics, temporal variability, and intensity of light pollution (Candolin, 2024).

6.6.2 Ecological Impacts

Understanding the intricate ecological impacts of light pollution demands further investigation. Research should explore the specific effects on various species, considering both direct and indirect consequences (Foster et al., 2018). Long-term studies that observe changes in wildlife behaviour, population dynamics, and ecosystem functioning in response to different

characteristics (e.g. spectra, intensity) of light pollution are essential to comprehensively grasp the ecological ramifications (Sanders et al., 2021).

6.6.3 Human Health Outcomes

Existing research suggests links between light pollution and human health issues (Cupertino et al 2023). Future studies should explore the nuanced mechanisms and long-term consequences. The impact of light pollution on specific health conditions, such as sleep disorders, mental health issues, and chronic diseases, can guide public health interventions and policies (Cupertino et al., 2023).

6.6.4 Cultural and Societal Impacts

The cultural and societal implications of light pollution warrant further assessment. Future research should investigate how altered perceptions of the night sky influence cultural practices, traditions, and human connection to the cosmos and nature (Pyle, 2002). Understanding the societal costs and benefits of artificial lighting is necessary for developing strategies that balance the need for light with the preservation of natural darkness (Luymes & Tamminga, 1995). Research suggests that stargazing is one of the easiest ways to produce a sense of awe in humans. A sense of awe is increasing with wellbeing and purpose (Keltner, 2023).

6.6.5 Mitigation Strategies

Efforts should focus on identifying and evaluating the effectiveness of mitigation strategies for light pollution. This includes assessing the impact of various outdoor lighting designs, implementing technological solutions, and understanding the effectiveness of community-driven initiatives (EU, 2023). Lighting design should not be an afterthought of new construction. Best practices for urban planning, public awareness campaigns, and policy interventions need to be informed by rigorous research (Grubisic et al., 2019).

6.6.6 Technological Innovations

Harnessing technological advancements for monitoring and mitigating light pollution represents a promising avenue for future research. Developing smart lighting systems, employing machine learning algorithms for real-time monitoring, and integrating citizen science initiatives can transform our ability to address light pollution.

Addressing the complex and multifaceted issue of light pollution requires a concerted and interdisciplinary research effort. By prioritizing these future research needs, the scientific community can contribute significantly to developing evidence-based solutions that promote sustainable lighting practices, preserve natural darkness, and mitigate the far-reaching impacts of light pollution on ecosystems, human health, and society.

6.6.7 Climate change

Global warming, particularly in populated areas, is leading to an increase in human activities at night. For instance, in Dubai, nighttime activities are on the rise, with lights illuminating public beaches (Agathokleous, 2023). Recent studies suggest that continuous artificial lighting may make coastal zooplankton more vulnerable, especially as climate change affects coastal environments (Nguyen et al., 2020). The rising temperatures at night can interact with artificial light at night (ALAN), altering the nocturnal environment. This change can impact the physiology and behaviour of both daytime and nighttime organisms, affecting their fitness, survival, and roles within their ecosystems (Tougeron and Sanders, 2023). The growing human demand for nighttime lighting, combined with the effects of night-time warming and ALAN, is significantly impacting nocturnal environments. Therefore, there is a significant need for improved lighting design to mitigate light pollution.

6.7 Summary

The key findings and arguments presented in this chapter emphasise the urgent need for global, community, and individual action to safeguard natural night skies. Continued efforts to promote educational videos and nature experiences are tools for environmental education and advocacy that may foster knowledge, awareness, and motivation in younger generations to be more engaged in creating solutions. By recognizing the economic and non-economic value of dark skies, I have charted a path towards a more sustainable, just, and desirable future.

References

- Abraham, H., Scantlebury, D. M., & Zubidat, A. E. (2019). The loss of ecosystem-services emerging from artificial light at night. *Chronobiology International*, 36(2), Article 2. <https://doi.org/10.1080/07420528.2018.1534122>
- Ai, G. (2003). - Chinese Astronomy in the Century Transition. In Y. Lu (Ed.), *Science Progress in China* (pp. 284–298). Elsevier Science Ltd. <https://doi.org/10.1016/B978-008044970-8/50052-X>
- Alleway, H. K., Klein, E. S., Cameron, L., Douglass, K., Govia, I., Guell, C., Lim, M., Robin, L., & Thurstan, R. H. (2023). The shifting baseline syndrome as a connective concept for more informed and just responses to global environmental change. *People and Nature*, 5(3), 885–896. <https://doi.org/10.1002/pan3.10473>
- Bara, S., & Falchi, F. (2023). Artificial light at night: A global disruptor of the night-time environment. *Philosophical Transactions of the Royal Society B*, 378(20220352). <https://doi-org.du.idm.oclc.org/10.1098/rstb.2022.0352>
- Barentine, J. C., Walker, C. E., Kocifaj, M., Kundracik, F., Juan, A., Kanemoto, J., & Monrad, C. K. (2018). Skyglow changes over Tucson, Arizona, resulting from a municipal LED street lighting conversion. *Journal of Quantitative Spectroscopy and Radiative Transfer*, 212, 10–23. <https://doi.org/10.1016/j.jqsrt.2018.02.038>
- Barragan, R.C., & Meltzoff, A.N. (2024). Opportunity to view the starry night sky is linked to human emotion and behavioral interest in astronomy. *Science Report* 14, 19314. <https://doi-org.du.idm.oclc.org/10.1038/s41598-024-69920-4>
- Bell, R., Irvine, K. N., Wilson, C., & Waber, S. L. (2014). Dark Nature: Exploring potential benefits of nocturnal nature-based interactions for human and environmental health. *European Journal of Ecopsychology*, 5, 1–15.

- Bennie, J., Duffy, J. P., Davies, T. W., Correa-Cano, M. E., & Gaston, K. J. (2015). Global Trends in Exposure to Light Pollution in Natural Terrestrial Ecosystems. *Remote Sensing*, 7(3), 2715–2730. <https://doi.org/10.3390/rs70302715>
- Bhathal, R. (2006). Astronomy in Aboriginal culture. *Astronomy & Geophysics*, 47(5), 5.27-5.30. <https://doi.org/10.1111/j.1468-4004.2006.47527.x>
- Birriel, J. J., Adkins, J. K., & Fagan, A. (2023). Why every astronomy class should devote time to light pollution education. *Physics Teacher*, 61(5), Article 5. <https://doi.org/10.1119/5.0149904>
- Boluda-Verdú, I., Senent-Valero, M., Casas-Escolano, M., Matijasevich, A., & Pastor-Valero, M. (2022). Fear for the future: Eco-anxiety and health implications, a systematic review. *Journal of Environmental Psychology*, 84, 101904. <https://doi.org/10.1016/j.jenvp.2022.101904>
- Boner, P. (2021). Chapter 4 Celestial Novelty and the Science of the Stars: Kepler vs. Krabbe on Accuracy and Authority in Early Modern Germany. In *Kepler's New Star (1604)*. Brill. <https://lccn.loc.gov/2020042171>
- Bortle, J. E. (2001). The Bortle Dark-Sky Scale. *Sky and Telescope*.
- Bowen, A. (2020). Some Early Hypotheses in Greco-Roman Astronomy. In *Hellenistic Astronomy* (pp. 95–111). Brill. https://doi.org/10.1163/9789004400566_014
- Bozejko, M., Tarski, I., & Malodobra-Mazur, M. (2023). Outdoor artificial light at night and human health: A review of epidemiological studies. *Environmental Research*, 218. <https://doi.org/10.1016/j.envres.2022.115049>
- Brown, G., Schebella, M. F., & Weber, D. (2014). Using participatory GIS to measure physical activity and urban park benefits. *Landscape and Urban Planning*, 121, 34–44.

- Brown, M. (2016, May 20). Copernicus' revolution and Galileo's vision: Our changing view of the universe in pictures. *The Conversation*.
<https://theconversation.com/copernicus-revolution-and-galileos-vision-our-changing-view-of-the-universe-in-pictures-60103>
- Bucher, S. F., Uhde, L., Weigelt, A., Cesarz, S., Eisenhauer, N., Gebler, A., Kyba, C., Römermann, C., Shatwell, T., & Hines, J. (2023). Artificial light at night decreases plant diversity and performance in experimental grassland communities. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 378(1892), Article 1892.
<https://doi.org/10.1098/rstb.2022.0358>
- Buchhorn, M. ; Smets, B. ; Bertels, L. ; De Roo, B. ; Lesiv, M. ; Tsendbazar, N. - E. ; Herold, M. ; Fritz, S. (2022). *Copernicus Global Land Service: Land Cover 100m: Collection 3: Epoch 2015: Globe* [dataset]. <https://doi.org/10.5281/zenodo.3939038>
- Cabrera-Cruz, S. A., Smolinsky, J. A., McCarthy, K. P., & Buler, J. J. (2019). Urban areas affect flight altitudes of nocturnally migrating birds. *Journal of Animal Ecology*, 88(12), Article 12. <https://doi.org/10.1111/1365-2656.13075>
- Cajete, G. (2009). The Alaska Native Reader. In M. S. T. Williams, R. Kirk, & O. Starn (Eds.), *History, Culture, Politics* (pp. 230–236). Duke University Press.
<https://doi.org/10.1515/9780822390831-024>
- Candolin, U. (2024). Coping with light pollution in urban environments: Patterns and challenges. *iScience*, 27(3), Article 3. <https://doi.org/10.1016/j.isci.2024.109244>
- Capra, F. (2004). Development and sustainability. *Thresholds in Education*, 30(4), 21.
- Carr, V., & Plevyak, L. (n.d.). Early Childhood Environmental Education in the USA: Baby Steps Toward a Sustainable Worldview. In *Researching Early Childhood Education for Sustainability: Challenging Assumptions and Orthodoxies* (1st ed., pp. 94–108). Routledge.

<https://www.taylorfrancis.com/chapters/edit/10.4324/9780429446764-8/early-childhood-environmental-education-usa-victoria-carr-linda-plevyak?context=ubx&refId=10218a16-e639-4196-aac3-414dfc3732a6>

- Chen, S. K., & Mongrain, M. (2021). Awe and the interconnected self. *The Journal of Positive Psychology*, 16(6), Article 6. <https://doi.org/10.1080/17439760.2020.1818808>
- Cho, Y., Ryu, S.-H., Lee, B. R., Kim, K. H., Lee, E., & Choi, J. (2015). Effects of artificial light at night on human health: A literature review of observational and experimental studies applied to exposure assessment. *Chronobiology International*, 32(9), Article 9. <https://doi.org/10.3109/07420528.2015.1073158>
- Clark, S. (2020). *Beneath the Night: How the stars have shaped the history of humankind*. Guardian Faber Publishing. <https://books.google.com/books?id=HkfQDwAAQBAJ>
- Clayton, S. (n.d.). Environmental Identity: A Conceptual and an Operational Definition. In S. Clayton & S. Opatow (Eds.), *Identity and the natural environment: The psychological significance of nature* (pp. 45–65). MIT Press.
- Commission, E., & Environment, D.-G. for. (2023). *How to mitigate night-time artificial light pollution impacts on the environment? – Find more in our future brief!* Publications Office of the European Union. <https://doi.org/doi/10.2779/941781>
- Colucci-Gray, L., Camino, E., Barbiero, G., & Gray, D. (2006). From scientific literacy to sustainability literacy: An ecological framework for education. *Science Education*, 90(2), 227–252.
- Consolmagno, G. (2009). *The Heavens Proclaim: Astronomy and the Vatican*. Our Sunday Visitor.
- Costanza, R., Groot, R. de, Sutton, P., Ploeg, S. van der, Anderson, S. J., Kubiszewski, I., Farber, S., & Turner, R. K. (2014). Changes in the global value of ecosystem services.

Global Environmental Change, 26, 152–158.

<https://doi.org/10.1016/j.gloenvcha.2014.04.002>

Couprie, D. (2011). *Heaven and Earth in Ancient Greek Cosmology: From Thales to*

Heraclides Ponticus. Springer Science+Business Media.

Cupertino, M. D. C., Guimarães, B. T., Pimenta, J. F. G., Almeida, L. V. L. D., Santana, L.

N., Ribeiro, T. A., & Santana, Y. N. (2023). Light Pollution: a systematic review about the impacts of artificial light on human health. *Biological Rhythm Research*,

54(3), Article 3. <https://doi.org/10.1080/09291016.2022.2151763>

Czaja, M., & Kolton, A. (2022). How light pollution can affect spring development of urban trees and shrubs. *Urban Forestry & Urban Greening*, 77, 127753.

<https://doi.org/10.1016/j.ufug.2022.127753>

Dananay, K. L., & Benard, M. F. (2018). Artificial light at night decreases metamorphic

duration and juvenile growth in a widespread amphibian. *Proceedings of the Royal Society B: Biological Sciences*, 285(1882), Article 1882.

DarkSky. (n.d.). *What is Light Pollution?* Retrieved January 6, 2024, from darksky.org

Davies, T. W., Duffy, J. P., Bennie, J., & Gaston, K. J. (2014). The nature, extent, and ecological implications of marine light pollution. *Frontiers in Ecology and The*

Environment, 12(6), Article 6. <https://doi.org/10.1890/130281>

Davies, T. W., & Smyth, T. (2018a). Why artificial light at night should be a focus for global change research in the 21st century. *Global Change Biology*, 24(3), 872–882.

<https://doi.org/10.1111/gcb.13927>

Davies, T. W., & Smyth, T. (2018b). Why artificial light at night should be a focus for global change research in the 21st century. *Global Change Biology*, 24(3), Article 3.

<https://doi.org/10.1111/gcb.13927>

- Davis, L. K., Bumgarner, J. R., Nelson, R. J., & Fonken, L. K. (2023). Health Effects of Disrupted Circadian Rhythms by Artificial Light at Night. *Policy Insights from the Behavioral and Brain Sciences*, 10(2), 229–236.
<https://doi.org/10.1177/23727322231193967>
- DCCEEW. (2023). *National Light Pollution Guidelines for Wildlife*. Department of Climate Change, Energy, the Environment and Water.
- Deane, T. E. (1994). Instruments and Observation at the Imperial Astronomical Bureau during the Ming Dynasty. *Osiris*, 9, 126–140. JSTOR.
- Dickerson, A. L., Hall, M. L., & Jones, T. M. (2022). The effect of natural and artificial light at night on nocturnal song in the diurnal willie wagtail. *Science of The Total Environment*, 808, 151986. <https://doi.org/10.1016/j.scitotenv.2021.151986>
- Ditmer, M. A., Stoner, D. C., Francis, C. D., Barber, J. R., Forester, J. D., Choate, D. M., Ironside, K. E., Longshore, K. M., Hersey, K. R., Larsen, R. T., McMillan, B. R., Olson, D. D., Andreasen, A. M., Beckmann, J. P., Holton, P. B., Messmer, T. A., & Carter, N. H. (2021). Artificial nightlight alters the predator–prey dynamics of an apex carnivore. *Ecography*, 44(2), Article 2. <https://doi.org/10.1111/ecog.05251>
- Dominoni, D. M., Halfwerk, W., Baird, E., Buxton, R. T., Fernández-Juricic, E., Fristrup, K. M., McKenna, M. F., Mennitt, D. J., Perkin, E. K., Seymoure, B. M., Stoner, D. C., Tennessen, J. B., Toth, C. A., Tyrrell, L. P., Wilson, A., Francis, C. D., Carter, N. H., & Barber, J. R. (2020). Why conservation biology can benefit from sensory ecology. *Nature Ecology & Evolution*, 4(4), 502–511. <https://doi.org/10.1038/s41559-020-1135-4>
- DUALI, Ş. M. (2022). Hristiyanlık Öncesi Gürcü Tanrılar Panteonu. *Hitit İlahiyat Dergisi*, 21(1), Article 1. <https://doi.org/10.14395/hid.1064534>

- Dyer, A., Ryser, R., Brose, U., Amyntas, A., Bodnar, N., Boy, T., Franziska Bucher, S., Cesarz, S., Eisenhauer, N., Gebler, A., Hines, J., Kyba, C. C. M., Menz, M. H. M., Rackwitz, K., Shatwell, T., Terlau, J. F., & Hirt, M. R. (2023). Insect communities under skyglow: Diffuse night-time illuminance induces spatio-temporal shifts in movement and predation. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 378(1892), 20220359. <https://doi.org/10.1098/rstb.2022.0359>
- Ehrenfeld, D. (2008). *Becoming good ancestors: How we balance nature, community, and technology*. Oxford University Press.
- Elvidge, C. D., Baugh, K., Zhizhin, M., Hsu, F. C., & Ghosh, T. (2017). VIIRS night-time lights. *International Journal of Remote Sensing*, 38(21), Article 21.
- Agathokleous, E. (2023). Light pollution driven by climate change. *Science* 382,655-655(2023). DOI:10.1126/science.adk7733
- Falchi, F., Cinzano, P., Duriscoe, D., Kyba, C. C., Elvidge, C. D., Baugh, K., Portnov, B. A., Rybnikova, N. A., & Furgoni, R. (2016). The new world atlas of artificial night sky brightness. *Science Advances*, 2(6), Article 6.
- Falchi, F., Furgoni, R., Gallaway, T. A., Rybnikova, N. A., Portnov, B. A., Baugh, K., Cinzano, P., & Elvidge, C. D. (2019). Light pollution in USA and Europe: The good, the bad and the ugly. *Journal of Environmental Management*, 248, 109227. <https://doi.org/10.1016/j.jenvman.2019.06.128>
- Falcón, J., Torriglia, A., Attia, D., Viénot, F., Gronfier, C., Behar-Cohen, F., Martinsons, C., & Hicks, D. (2020). Exposure to Artificial Light at Night and the Consequences for Flora, Fauna, and Ecosystems. *Frontiers in Neuroscience*, 14. <https://doi.org/10.3389/fnins.2020.602796>

- Fang, C. (2012). Past, Present and Future of Chinese Astronomy. *Proceedings of the International Astronomical Union*, 10(H16), Article H16.
<https://doi.org/10.1017/S1743921314004621>
- Firebaugh, A., & Haynes, K. J. (2019). Light pollution may create demographic traps for nocturnal insects. *Basic and Applied Ecology*, 34, 118–125.
<https://doi.org/10.1016/j.baae.2018.07.005>
- Foster, J. J., Smolka, J., Nilsson, D.-E., & Dacke, M. (2018). How animals follow the stars. *Proceedings of the Royal Society B: Biological Sciences*, 285(1871), Article 1871.
- Fraknoi, A., Morrison, D., & Wolff, S. (2017). *Astronomy*. OpenStax.
<https://pressbooks.online.ucf.edu/astronomybc/>
- Fuller, R., Anderson, M., Norris, R., & Trudgett, M. (2014). *The Emu Sky Knowledge of the Kamilaroi and Euahlayi Peoples*. <https://arxiv.org/abs/1403.0304>
- Gandy, M. (2017). Negative Luminescence. *Annals of the American Association of Geographers*, 107(5), Article 5. <https://doi.org/10.1080/24694452.2017.1308767>
- Ganguly, A., & Candolin, U. (2023). Impact of light pollution on aquatic invertebrates: Behavioral responses and ecological consequences. *Behavioral Ecology and Sociobiology*, 77(9). <https://doi.org/10.1007/s00265-023-03381-z>
- Garza-Teran, G., Fonllem, C., Fraijo-Sing, B., & Moreno-Barahona, M. (2022). Effects of Being in Contact with Nature on Individuals' Nature Connectedness: Excursion on the “Pinacate y Gran Desierto de Altar” Biosphere Reserve. *Ecopsychology*, 14(3), Article 3. <https://doi.org/10.1089/eco.2022.0003>
- Gaston, K. J., Bennie, J., Davies, T. W., & Hopkins, J. (2013). The ecological impacts of nighttime light pollution: A mechanistic appraisal. *Biological Reviews*, 88(4), 912–927. <https://doi.org/10.1111/brv.12036>

- Gaston, K. J., Davies, T. W., Bennie, J., & Hopkins, J. (2012). REVIEW: Reducing the ecological consequences of night-time light pollution: Options and developments. *Journal of Applied Ecology*, 49(6), Article 6. <https://doi.org/10.1111/j.1365-2664.2012.02212.x>
- Gaston, K. J., Gaston, S., Bennie, J., & Hopkins, J. (2015). Benefits and costs of artificial nighttime lighting of the environment. *Environmental Reviews*, 23(1), 14–23. <https://doi.org/10.1139/er-2014-0041>
- Gaston, K. J., & Sanchez de Miguel, A. (2022). Environmental Impacts of Artificial Light at Night. *Annual Review of Environment and Resources*, 47, 373–398. <https://doi.org/10.1146/annurev-environ-112420-014438>
- Geng, L., Xu, J., Ye, L., Zhou, W., & Zhou, K. (2015). Connections with Nature and Environmental Behaviors. *PLOS ONE*, 10(5), 1–11. <https://doi.org/10.1371/journal.pone.0127247>
- Gianfredi, V., Mazziotta, F., Clerici, G., Astorri, E., Olini, F., Cappellina, M., Catalini, A., Dell’Osso, B. M., Pregliasco, F. E., Castaldi, S., & Benatti, B. (2024). Climate Change Perception and Mental Health. Results from a Systematic Review of the Literature. *European Journal of Investigation in Health, Psychology and Education*, 14(1), Article 1. <https://doi.org/10.3390/ejihpe14010014>
- Gianotti, C., González-García, A. C., Gazzán, N., Cancela-Cereijo, C., & Sotelo, M. (2023). Knowledge of the Sky among Indigenous Peoples of the South American Lowlands—First Archaeoastronomical Analyses of Orientations at Mounds in Uruguay. *Land*, 12(4). <https://doi.org/10.3390/land12040805>
- Giavi, S., Bloesch, S., Schuster, G., & Knop, E. (2020). Artificial light at night can modify ecosystem functioning beyond the lit area. *Scientific Reports*, 10(1), Article 1. <https://doi.org/10.1038/s41598-020-68667-y>

- Green, K., Caley, P., Baker, M., Dreyer, D., Wallace, J., & Warrant, E. (2021). Australian Bogong moths *Agrotis infusa* (Lepidoptera: Noctuidae), 1951-2020: Decline and crash. *Austral Entomology*, 60(1), Article 1. <https://doi.org/10.1111/aen.12517>
- Grubisic, M., Haim, A., Bhusal, P., Dominoni, D. M., Gabriel, K. M. A., Jechow, A., Kupprat, F., Lerner, A., Marchant, P., Riley, W., Stebelova, K., van Grunsven, R. H. A., Zeman, M., Zubidat, A. E., & Hölker, F. (2019). Light Pollution, Circadian Photoreception, and Melatonin in Vertebrates. *Sustainability*, 11(22), Article 22. <https://doi.org/10.3390/su11226400>
- Gaut, B. (2022). Group Creativity. *Royal Institute of Philosophy Supplement*, 92, 5–26. <https://doi.org/10.1017/S1358246122000145>
- Häggström, M., & Schmidt, C. (2020). Enhancing children's literacy and ecological literacy through critical place-based pedagogy. *Environmental Education Research*, 26(12), 1729–1745. <https://doi.org/10.1080/13504622.2020.1812537>
- Hamacher, D., De Napoli, K., & Mott, B. (n.d.). Whitening the Sky: Light pollution as a form of cultural genocide. *Journal of Dark Sky Studies*, 1, pre-print.
- Hannah, R. (2015). The roles of observational astronomy in ancient Greece. *Scientific Culture*, 1(2), 47–56.
- Harmacher, D. (2024, February 11). *Australian Indigenous Astronomy*. <http://www.aboriginalastronomy.com.au/>
- Hartung, H. (1984). Alignments in Architecture and Sculpture of Maya Centres: Notes on Piedras Negras, Copán and Chichén Itzá. *Ibero-Amerikanisches Archiv*, 10(2), 223–240. JSTOR.
- Hayden, B., Bowdler, S., Butzer, K. W., Cohen, M. N., Druss, M., Dunnell, R. C., Goodyear, A. C., Hardesty, D. L., Hassan, F. A., Kamminga, J., Lourandos, H., Matson, R. G., Miller, P., Mohapatra, G. C., Persson, P., Pittioni, R., Valoch, K.,

- Wymer, J. J., & Yesner, D. R. (1981). Research and Development in the Stone Age: Technological Transitions among Hunter-Gatherers [and Comments and Reply]. *Current Anthropology*, 22(5), Article 5. JSTOR.
- Hayden, B., & Villeneuve, S. (2011). Astronomy in the Upper Palaeolithic? *Cambridge Archaeological Journal*, 21(3), 331–355. Cambridge Core.
<https://doi.org/10.1017/S0959774311000400>
- Health Promotion Board. (2011). *Singapore achieves breakthrough in reducing prevalence of myopia by almost 5%*. Singapore Government.
<https://www.hpb.gov.sg/newsroom/article/singapore-achieves-breakthrough-in-reducing-prevalence-of-myopia-by-almost-5>
- Hickel, J. (2019). The contradiction of the sustainable development goals: Growth versus ecology on a finite planet. *Sustainable Development*, 27(5), 873–884.
<https://doi.org/10.1002/sd.1947>
- Hickel, J. (2020). *Less is more: How degrowth will save the world*. Random House.
- Hoag, A. A., Schoening, W. E., & Coucke, M. (1973). City Sky Glow Monitoring at Kitt Peak. *Publications of the Astronomical Society of the Pacific*, 85(507), 503–507.
<http://www.jstor.org/stable/40675429>
- Hoelker, F., Bolliger, J., Davies, T. W., Giavi, S., Jechow, A., Kalinkat, G., Longcore, T., Spoelstra, K., Tidau, S., Visser, M. E., & Knop, E. (2021). 11 Pressing Research Questions on How Light Pollution Affects Biodiversity. *Frontiers in Ecology and Evolution*, 9. <https://doi.org/10.3389/fevo.2021.767177>
- Hoelker, F., Moss, T., Griefahn, B., Kloas, W., Voigt, C. C., Henckel, D., Haenel, A., Kappeler, P. M., Voelker, S., Schwoppe, A., Franke, S., Uhrlandt, D., Fischer, J., Klenke, R., Wolter, C., & Tockner, K. (2010). The Dark Side of Light: A

- Transdisciplinary Research Agenda for Light Pollution Policy. *Ecology and Society*, 15(4), Article 4.
- Hölker, F., Jechow, A., Schroer, S., Tockner, K., & Gessner, M. O. (2023). Light pollution of freshwater ecosystems: Principles, ecological impacts and remedies. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 378(1892), 20220360.
<https://doi.org/10.1098/rstb.2022.0360>
- Horton, K. G., Buler, J. J., Anderson, S. J., Burt, C. S., Collins, A. C., Dokter, A. M., Guo, F., Sheldon, D., Tomaszewska, M. A., & Henebry, G. M. (2023). Artificial light at night is a top predictor of bird migration stopover density. *Nature Communications*, 14(1), Article 1.
- Horton, K. G., Nilsson, C., Van Doren, B. M., La Sorte, F. A., Dokter, A. M., & Farnsworth, A. (2019). Bright lights in the big cities: Migratory birds' exposure to artificial light. *Frontiers in Ecology and the Environment*, 17(4), Article 4.
- Hung, L.-W., Anderson, S. J., Pipkin, A., & Fristrup, K. (2021). Changes in night sky brightness after a countywide LED retrofit. *Journal of Environmental Management*, 292. <https://doi.org/10.1016/j.jenvman.2021.112776>
- Hutton, R. (n.d.). Prehistoric British Astronomy: Whatever Happened to the Earth and Sun? *Culture and Cosmos*, 18(1), 21–35.
- Iwata, N., Ichii, S., & Egashira, K. (1997). Effects of bright artificial light on subjective mood of shift work nurses. *Industrial Health*, 35(1), Article 1.
<https://doi.org/10.2486/indhealth.35.41>
- Jägerbrand, A. K., & Spoelstra, K. (2023). Effects of anthropogenic light on species and ecosystems. *Science*, 380(6650), Article 6650.

- Jechow, A., Kyba, C. C. M., & Hölker, F. (2020). Mapping the brightness and color of urban to rural skyglow with all-sky photometry. *Journal of Quantitative Spectroscopy and Radiative Transfer*, 250, 106988. <https://doi.org/10.1016/j.jqsrt.2020.106988>
- Jones, L. P., Turvey, S. T., & Papworth, S. K. (2021). Is there evidence of shifting baseline syndrome in environmental managers? An assessment using perceptions of bird population targets in UK nature reserves. *Journal of Environmental Management*, 297, 113308. <https://doi.org/10.1016/j.jenvman.2021.113308>
- Kamrowski, R. L., Sutton, S. G., Tobin, R. C., & Hamann, M. (2015). Balancing artificial light at night with turtle conservation? Coastal community engagement with light-glow reduction. *Environmental Conservation*, 42(2), Article 2. <https://doi.org/10.1017/S0376892914000216>
- Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, 15(3), 169–182. [https://doi.org/10.1016/0272-4944\(95\)90001-2](https://doi.org/10.1016/0272-4944(95)90001-2)
- Katabaro, J. M., Yan, Y., Hu, T., Yu, Q., & Cheng, X. (2022). A review of the effects of artificial light at night in urban areas on the ecosystem level and the remedial measures. *Frontiers in Public Health*, 10. <https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2022.969945>
- Kellert, S., & Wilson, E. O. (1995). The Biophilia Hypothesis, Stephen R. Kellert and Edward O. Wilson. 1993. Island Press, Washington, DC. 484 pages. ISBN: 1-55963-148-1. \$27.50. *Bulletin of Science, Technology & Society*, 15(1), Article 1. <https://doi.org/10.1177/027046769501500125>
- Kellert, S. R. (2012). *Building for life: Designing and understanding the human-nature connection*. Island press.

- Keniger, L. E., Gaston, K. J., Irvine, K. N., & Fuller, R. A. (2013). What are the Benefits of Interacting with Nature? *International Journal of Environmental Research and Public Health*, 10(3), 913–935. <https://doi.org/10.3390/ijerph10030913>
- Kenneth Ch'en, & Ricci, M. (1939). Matteo Ricci's Contribution to, and Influence on, Geographical Knowledge in China. *Journal of the American Oriental Society*, 59(3), Article 3. JSTOR. <https://doi.org/10.2307/594690>
- Kernbach, M. E., Miller, C., Alaasam, V., Ferguson, S., & Francis, C. D. (2021). Introduction to the Symposium: Effects of Light Pollution Across Diverse Natural Systems. *Integrative and Comparative Biology*, 61(3), 1089–1097. <https://doi.org/10.1093/icb/icab157>
- Kimmerer, R. W. (2015). *Braiding Sweetgrass*. Milkweed Editions.
- Knop, E., Zoller, L., Ryser, R., Gerpe, C., Hörler, M., & Fontaine, C. (2017). Artificial light at night as a new threat to pollination. *Nature*, 548(7666), 206–209. <https://doi.org/10.1038/nature23288>
- Koo, Y. S., Song, J.-Y., Joo, E.-Y., Lee, H.-J., Lee, E., Lee, S., & Jung, K.-Y. (2016). Outdoor artificial light at night, obesity, and sleep health: Cross-sectional analysis in the KoGES study. *Chronobiology International*, 33(3), Article 3. <https://doi.org/10.3109/07420528.2016.1143480>
- Kotera, Y., Richardson, M., & Sheffield, D. (n.d.). Effects of shinrin-yoku (forest bathing) and nature therapy on mental health: A systematic review and meta-analysis. *International Journal of Mental Health and Addiction*, 1–25.
- Kraus, Louis. (2016). *Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting* (Report Of The Council On Science And Public Health CSAPH Report 2-A-16; Issue CSAPH Report 2-A-16). American Medical Association.

- Kyba, C. C. M., Altintas, Y. O., Walker, C. E., & Newhouse, M. (2023). Citizen scientists report global rapid reductions in the visibility of stars from 2011 to 2022. *Science*, 379(6629), Article 6629. <https://doi.org/10.1126/science.abq7781>
- Kyba, C. C. M., Kuester, T., Sanchez de Miguel, A., Baugh, K., Jechow, A., Hoelker, F., Bennie, J., Elvidge, C. D., Gaston, K. J., & Guanter, L. (2017). Artificially lit surface of Earth at night increasing in radiance and extent. *Science Advances*, 3(11), Article 11. <https://doi.org/10.1126/sciadv.1701528>
- Lanca, C., & Saw, S.-M. (2020). The association between digital screen time and myopia: A systematic review. *Ophthalmic and Physiological Optics*, 40(2), 216–229. <https://doi.org/10.1111/opo.12657>
- Le Tallec, T., Perret, M., & Théry, M. (2013). Light Pollution Modifies the Expression of Daily Rhythms and Behavior Patterns in a Nocturnal Primate. *PLOS ONE*, 8(11), Article 11. <https://doi.org/10.1371/journal.pone.0079250>
- Lemmey, T. (2020). *Connection with Nature in the UK during the COVID-19 Lockdown*. University of Cumbria. <https://insight.cumbria.ac.uk/id/eprint/5639/1/Nature%20Connection%20and%20Covid%20TL.pdf>
- Levy, O., Marangoni, L. F. de B., Benichou, J. I. C., Rottier, C., Beraud, E., Grover, R., & Ferrier-Pages, C. (2020). Artificial light at night (ALAN) alters the physiology and biochemistry of symbiotic reef building corals. *Environmental Pollution*, 266(2), Article 2. <https://doi.org/10.1016/j.envpol.2020.114987>
- Lewanzik, D., & Voigt, C. C. (2014). Artificial light puts ecosystem services of frugivorous bats at risk. *Journal of Applied Ecology*, 51(2), 388–394. <https://doi.org/10.1111/1365-2664.12206>

- Limpus, C., & Kamrowski, R. L. (2013). Ocean-finding in marine turtles: The importance of low horizon elevation as an orientation cue. *Behaviour*, 150(8), Article 8.
<https://doi.org/10.1163/1568539X-00003083>
- Liu, Y., Yu, C., Wang, K., Kwan, M., & Tse, L. (2023). Linking Artificial Light at Night with Human Health via a Multi-Component Framework: A Systematic Evidence Map. *Environments*, 10(3). <https://doi.org/10.3390/environments10030039>
- LOC. (2024). Ancient Greek Astronomy and Cosmology. In *Library of Congress*.
<https://www.loc.gov/collections/finding-our-place-in-the-cosmos-with-carl-sagan/articles-and-essays/modeling-the-cosmos/ancient-greek-astronomy-and-cosmology/>
- Longcore, T., & Rich, C. (2004). Ecological light pollution. *Frontiers in Ecology and the Environment*, 2(4), Article 4.
- Louv, R. (2005). *Last Child in the Woods: Saving Our Children From Nature-Deficit Disorder*. Algonquin Books.
- Luke, M. (2020, July 18). Aussies urged to fly a kite for sight. *Probono Australia*.
<https://probonoaustralia.com.au/news/2020/07/aussies-urged-to-fly-a-kite-for-sight/>
- Luymes, D. T., & Tamminga, K. (1995). Integrating public safety and use into planning urban greenways. *Landscape and Urban Planning*, 33(1–3), Article 1–3.
- Lyytimäki, J. (2013). Nature’s nocturnal services: Light pollution as a non-recognised challenge for ecosystem services research and management. *Ecosystem Services*, 3, E44–E48. <https://doi.org/10.1016/j.ecoser.2012.12.001>
- Lyytimäki, J., & Rinne, J. (2013). Voices for the darkness: Online survey on public perceptions on light pollution as an environmental problem. *Journal of Integrative Environmental Sciences*, 10(2), Article 2.
<https://doi.org/10.1080/1943815X.2013.824487>

- Makemson, M. (1954). Astronomy in Primitive Religion. *The Journal of Bible and Religion*, 22(3), 163–171.
- Maller, C., Townsend, M., St Leger, L., Henderson-Wilson, C., Pryor, A., Prosser, L., & Moore, M. (2008). *Healthy parks, healthy people: The health benefits of contact with nature in a park context*. Deakin University and Parks Victoria.
<https://www.jstor.org/stable/43598108>
- Mappes, J., & Stevens, M. (n.d.). Chapter 9: Information use and sensory ecology. In *Evolutionary Behavioral Ecology* (pp. 148–161). Oxford University Press.
- Marangoni, L. F., Davies, T., Smyth, T., Rodríguez, A., Hamann, M., Duarte, C., Pendoley, K., Berge, J., Maggi, E., & Levy, O. (2022). Impacts of artificial light at night in marine ecosystems—A review. *Global Change Biology*, 28(18), Article 18.
- Marchant, P., Hale, J. D., & Sadler, J. P. (2020). Does changing to brighter road lighting improve road safety? Multilevel longitudinal analysis of road traffic collision frequency during the relighting of a UK city. *Journal of Epidemiology & Community Health*, 74(5), 467–472. <https://doi.org/10.1136/jech-2019-212208>
- Marshack, A. (n.d.). *The roots of civilization: The cognitive beginnings of man's first art, symbol and notation*.
- Maryboy, N. C. (2020). Process and Relationship in Indigenous Astronomy Connectivity of Mother Earth and Father Sky. *International Journal of Applied Science and Sustainable Development*, 2(2), 14–23.
- Mason, I. C., Grimaldi, D., Reid, K. J., Warlick, C. D., Malkani, R. G., Abbott, S. M., & Zee, P. C. (2022). Light exposure during sleep impairs cardiometabolic function. *Proceedings of The National Academy of Sciences of The United States of America*, 119(12), Article 12. <https://doi.org/10.1073/pnas.2113290119>

- Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature ☆. *Journal of Environmental Psychology*, 24, 503–515.
- Mazor, T., Levin, N., Possingham, H. P., Levy, Y., Rocchini, D., Richardson, A. J., & Kark, S. (2013). Can satellite-based night lights be used for conservation? The case of nesting sea turtles in the Mediterranean. *Biological Conservation*, 159, 63–72.
- McBride, B. B., Brewer, C. A., Berkowitz, A. R., & Borrie, W. T. (2013). Environmental literacy, ecological literacy, ecoliteracy: What do we mean and how did we get here? *Ecosphere*, 4(5), art67. <https://doi.org/10.1890/ES13-00075.1>
- Meng, L., Zhou, Y., Román, M. O., Stokes, E. C., Wang, Z., Asrar, G. R., Mao, J., Richardson, A. D., Gu, L., & Wang, Y. (2022). Artificial light at night: An underappreciated effect on phenology of deciduous woody plants. *PNAS Nexus*, 1(2), Article 2. <https://doi.org/10.1093/pnasnexus/pgac046>
- Meravi, N., & Prajapati, S. K. (2020). Effect street light pollution on the photosynthetic efficiency of different plants. *Biological Rhythm Research*, 51(1), Article 1. <https://doi.org/10.1080/09291016.2018.1518206>
- Miller, C. R., Barton, B. T., Zhu, L., Radeloff, V. C., Oliver, K. M., Harmon, J. P., & Ives, A. R. (2017). Combined effects of night warming and light pollution on predator–prey interactions. *Proceedings of the Royal Society B: Biological Sciences*, 284(1864), Article 1864. <https://doi.org/10.1098/rspb.2017.1195>
- Morrow, E., & Hutton, S. (2000). *Chicago Alley Lighting Project: Final Evaluation Report* (NCJ: 188494; p. 58). Illinois Criminal Justice Information Authority. <https://www.ojp.gov/ncjrs/virtual-library/abstracts/chicago-alley-lighting-project-final-evaluation-report>

- Muscogiuri, G., Poggiogalle, E., Barrea, L., Tarsitano, M. G., Garifalos, F., Liccardi, A., Pugliese, G., Savastano, S., Colao, A., Colao, A., Alviggi, C., Aprano, S., Barazzoni, R., Barrea, L., Beguinot, F., Belfiore, A., Bellastella, G., Bettini, S., Bifulco, G., ... Vettor, R. (2022). Exposure to artificial light at night: A common link for obesity and cancer? *European Journal of Cancer*, 173, 263–275.
<https://doi.org/10.1016/j.ejca.2022.06.007>
- Nadybal, S. M., Collins, T. W., & Grineski, S. E. (2020). Light pollution inequities in the continental United States: A distributive environmental justice analysis. *Environmental Research*, 189. <https://doi.org/10.1016/j.envres.2020.109959>
- Nakata, M., Hamacher, D., Warren, J., Byrne, A., Pagnucco, M., Harley, R., Venugopal, S., Thorpe, K., Neville, R., & Bolt, R. (2014). Using Modern Technologies to Capture and Share Indigenous Astronomical Knowledge. *Australian Academic & Research Libraries*, 45(2), Article 2. <https://doi.org/10.1080/00048623.2014.917786>
- Nell, E., & Ruggles, C. (2014). The Orientations of the Giza Pyramids and Associated Structures. *Journal for the History of Astronomy*, 45(3), 304–360.
<https://doi.org/10.1177/0021828614533065>
- Noe, K., Karjala, P., Sikkink, A., & Lodes, D. (2020). A Demonstration of Kilo Hōkū-Implementing Hawaiian Star Navigation Methods in Virtual Reality. *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–4.
<https://doi.org/10.1145/3334480.3383156>
- Noon, K., & De Napoli, K. (n.d.). *Astronomy Sky Country*.
- Noon, K., De Napoli, K., & Neale, M. (2022). *First Knowledges Astronomy: Sky Country*. Thames & Hudson. <https://books.google.com/books?id=18fwzgEACAAJ>

- Norris, R. P., & Hamacher, D. W. (2015). Australian Aboriginal Astronomy—An Overview. In C. L. N. Ruggles (Ed.), *Handbook of Archaeoastronomy and Ethnoastronomy* (pp. 2215–2222). https://doi.org/10.1007/978-1-4614-6141-8_238.
- Nguyen, T. T., Le, M. H., Doan, N. X., Pham, H. Q., Vu, M. T., & Dinh, K. V. (2020). Artificial light pollution increases the sensitivity of tropical zooplankton to extreme warming. *Environmental Technology & Innovation*, 20, 101179.
- Obayashi, K., Saeki, K., Iwamoto, J., Ikada, Y., & Kurumatani, N. (2014). Independent associations of exposure to evening light and nocturnal urinary melatonin excretion with diabetes in the elderly. *Chronobiology International*, 31(3), 394–400. <https://doi.org/10.3109/07420528.2013.864299>
- Olsen, R. N., Gallaway, T., & Mitchell, D. (2014). Modelling US light pollution. *Journal of Environmental Planning and Management*, 57(6), Article 6. <https://doi.org/10.1080/09640568.2013.774268>
- Orr, D. W. (1991). *Ecological literacy: Education and the transition to a postmodern world*. State University of New York Press.
- Orr, D. W. (2011). *Hope is an Imperative: The Essential David Orr*. Island Press.
- Owens, A. C. S., Cochard, P., Durrant, J., Farnworth, B., Perkin, E. K., & Seymoure, B. (2020). Light pollution is a driver of insect declines. *Biological Conservation*, 241, 108259. <https://doi.org/10.1016/j.biocon.2019.108259>
- Papworth, S. K., Rist, J., Coad, L., & Milner-Gulland, E. J. (2009). Evidence for shifting baseline syndrome in conservation. *Conservation Letters*, 2(2), Article 2. <https://doi.org/10.1111/j.1755-263X.2009.00049.x>
- Parker, K., & Igielnik, R. (2022, June 6). *On the cusp of adulthood and facing an uncertain future: What we know about Gen Z so far*. [Pew Research Centre].

<https://www.pewresearch.org/social-trends/2020/05/14/on-the-cusp-of-adulthood-and-facing-an-uncertain-future-what-we-know-about-gen-z-so-far-2/>

- Pauly, D. (1995). Anecdotes and the shifting baseline syndrome of fisheries. *Trends in Ecology & Evolution*, 10(10), Article 10.
- Peregrym, M., Penzesne Konya, E., & Falchi, F. (2020). Very important dark sky areas in Europe and the Caucasus region. *Journal of Environmental Management*, 274.
<https://doi.org/10.1016/j.jenvman.2020.111167>
- Pitman, S. D., & Daniels, C. B. (2020). Understanding how nature works: Five pathways towards a more ecologically literate world – A perspective. *Austral Ecology*, 45(5), Article 5. <https://doi.org/10.1111/aec.12883>
- Pothukuchi, K. (2021). City Light or Star Bright: A Review of Urban Light Pollution, Impacts, and Planning Implications. *Journal of Planning Literature*, 36(2), 155–169.
<https://doi.org/10.1177/0885412220986421>
- Pothukuchi, K. (2023). Mitigating urban light pollution: A review of municipal regulations and implications for planners. *Journal of Urban Affairs*, 0(0), Article 0.
<https://doi.org/10.1080/07352166.2023.2247506>
- Poulin, C., Bruyant, F., Laprise, M.-H., Cockshutt, A. M., Marie-Rose Vandenhecke, J., & Huot, Y. (2014). The impact of light pollution on diel changes in the photophysiology of *Microcystis aeruginosa*. *Journal of Plankton Research*, 36(1), 286–291.
<https://doi.org/10.1093/plankt/fbt088>
- Pyle, R. M. (2002). Eden in a vacant lot: Special places, species, and kids in the neighborhood of life. *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations*, 305–327.
- Rabin, S. (2023). Nicolaus Copernicus. In *The Stanford Encyclopedia of Philosophy* (Winter 2023 Edition),. <https://plato.stanford.edu/archives/win2023/entries/copernicus/>

- Rajput, S., Naithani, M., Meena, K., & Rana, S. (2021). Light pollution: Hidden perils in light and links to cancer. *Sleep and Vigilance*, 5(1), Article 1.
<https://doi.org/10.1007/s41782-020-00123-3>
- Reed, G. (1986). Ancient Astronomers Along the Nile. *The Science Teacher*, 53(6), 59–62. JSTOR.
- Rich, C., & Longcore, T. (2013). *Ecological consequences of artificial night lighting*. Island Press.
- Ritonja, J., McIsaac, M. A., Sanders, E., Kyba, C. C. M., Grundy, A., Cordina-Duverger, E., Spinelli, J. J., & Aronson, K. J. (2020). Outdoor light at night at residences and breast cancer risk in Canada. *European Journal of Epidemiology*, 35(6), Article 6.
<https://doi.org/10.1007/s10654-020-00610-x>
- Robinson, J. M., & Breed, M. F. (2019). Green Prescriptions and Their Co-Benefits: Integrative Strategies for Public and Environmental Health. *Challenges*, 10(1), Article 1. <https://doi.org/10.3390/challe10010009>
- Rodrigo-Comino, J., Seeling, S., Seeger, M. K., & Ries, J. B. (2023). Light pollution: A review of the scientific literature. *The Anthropocene Review*, 10(2), 367–392.
<https://doi.org/10.1177/20530196211051209>
- Rodrigues, A. S. L., Monsarrat, S., Charpentier, A., Brooks, T. M., Hoffmann, M., Reeves, R., Palomares, M. L. D., & Turvey, S. T. (2019). Unshifting the baseline: A framework for documenting historical population changes and assessing long-term anthropogenic impacts. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 374(1788), Article 1788. <https://doi.org/10.1098/rstb.2019.0220>
- Rogers, J. H. (1998). Origins of the ancient constellations: II. The Mediterranean traditions. *Journal of the British Astronomical Association*, 108, 79–89.

- Rowse, E. G., Lewanzik, D., Stone, E. L., Harris, S., & Jones, G. (2016). Dark Matters: The Effects of Artificial Lighting on Bats. In C. C. Voigt & T. Kingston (Eds.), *Bats in the Anthropocene: Conservation of Bats in a Changing World* (pp. 187–213). Springer International Publishing. https://doi.org/10.1007/978-3-319-25220-9_7
- Ruggles, C. (n.d.). *Ancient Astronomy: An Encyclopedia of Cosmologies and Myth*. ABC-CLIO.
- Ruggles, C. (2010). *Indigenous Astronomies and Progress in Modern Astronomy*.
- Ruggles, C. L. N. (1997). Whose Equinox? *Journal for the History of Astronomy*, 28(22), S44–S50. <https://doi.org/10.1177/002182869702802205>
- Rybnikova, N., Haim, A., & Portnov, B. A. (2015). Artificial light at night (ALAN) and breast cancer incidence worldwide: A revisit of earlier findings with analysis of current trends. *Chronobiology International*, 32(6), Article 6.
- Salimpour, S., & Fitzgerald, M. T. (2022). Astronomy and Culture. *Science & Education*. <https://doi.org/10.1007/s11191-022-00389-1>
- Sánchez de Miguel, A., Bennie, J., Rosenfeld, E., Dzurjak, S., & Gaston, K. J. (2021). First Estimation of Global Trends in Nocturnal Power Emissions Reveals Acceleration of Light Pollution. *Remote Sensing*, 13(16), Article 16. <https://doi.org/10.3390/rs13163311>
- Sanders, D., Frago, E., Kehoe, R., Patterson, C., & Gaston, K. J. (2021). A meta-analysis of biological impacts of artificial light at night. *Nature Ecology & Evolution*, 5(1), 74–81. <https://doi.org/10.1038/s41559-020-01322-x>
- Sanders, D., & Gaston, K. J. (2018). How ecological communities respond to artificial light at night. *Journal of Experimental Zoology Part A-Ecological and Integrative Physiology*, 329(8–9, SI), Article 8–9, SI. <https://doi.org/10.1002/jez.2157>

- Santoni, A. (2012, November 1). A Map for Aratus. *Scientific Cosmopolitanism and Local Cultures: Religions, Ideologies, Societies*. 5th International Conference of the European Society for the History of Science, Athens.
https://pure.mpg.de/rest/items/item_2280639/component/file_2280638/content#page=36
- Schebella, M. F., Weber, D., Lindsey, K., & Daniels, C. B. (2017). For the love of nature: Exploring the importance of species diversity and micro-variables associated with favorite outdoor places. *Frontiers in Psychology*, 8, 2094.
- Schebella, M. F., Weber, D., Schultz, L., & Weinstein, P. (2019). The wellbeing benefits associated with perceived and measured biodiversity in Australian urban green spaces. *Sustainability*, 11(3), Article 3.
- Schebella, M. F., Weber, D., Schultz, L., & Weinstein, P. (2020). The Nature of Reality: Human Stress Recovery during Exposure to Biodiverse, Multisensory Virtual Environments. *International Journal of Environmental Research and Public Health*, 17(1). <https://doi.org/10.3390/ijerph17010056>
- Schiavina, Marcello; Freire, Sergio; Alessandra Carioli; MacManus, Kytt. (2020). *GHS-POP R2023A - GHS population grid multitemporal (1975-2030)* [dataset].
<https://doi.org/10.2905/2FF68A52-5B5B-4A22-8F40-C41DA8332CFE>
- Schneider, E. D., & Kay, J. J. (1994). Life as a manifestation of the second law of thermodynamics. *Mathematical and Computer Modelling*, 19, 25–48.
- Schultz, P. W., & Tabanico, J. (2007). Self, identity, and the natural environment: Exploring implicit connections with nature 1. *Journal of Applied Social Psychology*, 37(6), 1219–1247.
- Shapshay, S. (2021). What is the monumental. *The British Journal of Aesthetics*. 79(2), 145–160. [What Is the Monumental? | The Journal of Aesthetics and Art Criticism | Oxford Academic \(oup.com\)](https://www.oxfordacademic.com/doi/10.1093/aesthetics/jab001)

- Shelaih, R. (2022). Capricorn Image on Ancient Roman Coins. *Journal of Association of Arab Universities for Tourism and Hospitality*.
<https://api.semanticscholar.org/CorpusID:248198176>
- Silva, R., Medrano, F., Tejeda, I., Teran, D., Peredo, R., Barros, R., Colodro, V., Gonzalez, P., Gonzalez, V., Guerra-Correas, C., Hodum, P., Keitt, B., Luna-Jorquera, G., Malinarich, V., Mallea, G., Manriquez, P., Nevins, H., Olmedo, B., Paez-Godoys, J., ... Toro-Barros, B. (2020). Assessing light pollution impacts on seabirds in Chile: Diagnosis and proposals. *Ornitologia Neotropical*, 31, 13–24.
- Silva Sinha, V. da. (2019). Event-Based Time in Three Indigenous Amazonian and Xinguan Cultures and Languages. *Frontiers in Psychology*, 10.
<https://doi.org/10.3389/fpsyg.2019.00454>
- Smith, R. W. (1982). *The expanding universe: Astronomy's 'great debate', 1900-1931*. Cambridge University Press.
- Sobel, D. (2008). *Childhood and nature: Design principles for educators*. Stenhouse Publishers.
- Soga, M., & Gaston, K. J. (2018). Shifting baseline syndrome: Causes, consequences, and implications. *Frontiers in Ecology and The Environment*, 16(4), Article 4.
<https://doi.org/10.1002/fee.1794>
- Solano-Lamphar, H. A., & Kocifaj, M. (2018). Numerical research on the effects the skyglow could have in phytochromes and RQE photoreceptors of plants. *Journal of Environmental Management*, 209, 484–494.
<https://doi.org/10.1016/j.jenvman.2017.12.036>
- Sparks, P., Hinds, J., Curnock, S., & Pavey, L. (2014). Connectedness and its consequences: A study of relationships with the natural environment. *Journal of Applied Social Psychology*, 44(3), Article 3.

- Spoelstra, K., & Visser, M. E. (2013). The impact of artificial light on avian ecology. In D. Gil & H. Brumm (Eds.), *Avian Urban Ecology* (p. 0). Oxford University Press.
<https://doi.org/10.1093/acprof:osobl/9780199661572.003.0002>
- Stanley, M. C., Beggs, J. R., Bassett, I. E., Burns, B. R., Dirks, K. N., Jones, D. N., Linklater, W. L., Macinnis-Ng, C., Simcock, R., Souter-Brown, G., Trowsdale, S. A., & Gaston, K. J. (2015). Emerging threats in urban ecosystems: A horizon scanning exercise. *Frontiers in Ecology and The Environment*, 13(10), Article 10.
<https://doi.org/10.1890/150229>
- Sterckx, S., Benhadj, I., Duhoux, G., Livens, S., Dierckx, W., Goor, E., Adriaensen, S., Heyns, W., Van Hoof, K., Strackx, G., & others. (2014). The PROBA-V mission: Image processing and calibration. *International Journal of Remote Sensing*, 35(7), Article 7.
- Stone, E. L., Harris, S., & Jones, G. (2015). Impacts of artificial lighting on bats: A review of challenges and solutions. *Mammalian Biology*, 80(3, SI), Article 3, SI.
<https://doi.org/10.1016/j.mambio.2015.02.004>
- Sutton, P. C., & Anderson, S. J. (2016). Holistic valuation of urban ecosystem services in New York City's Central Park. *Ecosystem Services*, 19, 87–91.
<https://doi.org/10.1016/j.ecoser.2016.04.003>
- Sutton, P. C., Anderson, S. J., Costanza, R., & Kubiszewski, I. (2016). The ecological economics of land degradation: Impacts on ecosystem service values. *Ecological Economics*, 129, 182–192.
- Sutton, P. C., Cova, T. J., & Elvidge, C. D. (2006). Mapping “Exurbia” in the conterminous United States using nighttime satellite imagery. *Geocarto International*, 21(2), Article 2.

- Svechkina, A., Portnov, B. A., & Trop, T. (2020). The impact of artificial light at night on human and ecosystem health: A systematic literature review. *Landscape Ecology*, 35, 1725–1742.
- Sweatman, M. B., & Coombs, A. (2018). *Decoding European Palaeolithic art: Extremely ancient knowledge of precession of the equinoxes*.
- Szucs-Csillik, I. (2021). The message of some ancient astronomical symbols from the oldest neolithic vinc. A civilization (mostonga, tartaria, turdas and parta). *Romanian Astronomical Journal*, 31(2), Article 2.
- Tahkamo, L., Partonen, T., & Pesonen, A.-K. (2019). Systematic review of light exposure impact on human circadian rhythm. *Chronobiology International*, 36(2), Article 2.
<https://doi.org/10.1080/07420528.2018.1527773>
- Tancredi, S., Urbano, T., Vinceti, M., & Filippini, T. (2022). Artificial light at night and risk of mental disorders: A systematic review. *Science of The Total Environment*, 833.
<https://doi.org/10.1016/j.scitotenv.2022.155185>
- Tidau, S., Smyth, T., McKee, D., Wiedenmann, J., D'Angelo, C., Wilcockson, D., Ellison, A., Grimmer, A. J., Jenkins, S. R., Widdicombe, S., Queiros, A. M., Talbot, E., Wright, A., & Davies, T. W. (2021). Marine artificial light at night: An empirical and technical guide. *Methods in Ecology and Evolution*, 12(9), Article 9.
<https://doi.org/10.1111/2041-210X.13653>
- Tougeron, K., & Sanders, D. (2023). Combined light pollution and night warming as a novel threat to ecosystems. *Trends in Ecology & Evolution*, 38(8), 701-704.
- Touitou, Y., Reinberg, A., & Touitou, D. (2017). Association between light at night, melatonin secretion, sleep deprivation, and the internal clock: Health impacts and mechanisms of circadian disruption. *Life Sciences*, 173, 94–106.
<https://doi.org/10.1016/j.lfs.2017.02.008>

- Touzot, M., Lengagne, T., Secondi, J., Desouhant, E., Théry, M., Dumet, A., Duchamp, C., & Mondy, N. (2020). Artificial light at night alters the sexual behaviour and fertilisation success of the common toad. *Environmental Pollution*, 259, 113883. <https://doi.org/10.1016/j.envpol.2019.113883>
- TWB. (2022). *World Bank Official Boundaries* [dataset]. <https://datacatalog.worldbank.org/search/dataset/0038272/World-Bank-Official-Boundaries>
- Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, 11(3), 201–230. [https://doi.org/10.1016/S0272-4944\(05\)80184-7](https://doi.org/10.1016/S0272-4944(05)80184-7)
- Underwood, C. N., Davies, T. W., & Queiros, A. M. (2017). Artificial light at night alters trophic interactions of intertidal invertebrates. *Journal Of Animal Ecology*, 86(4), Article 4. <https://doi.org/10.1111/1365-2656.12670>
- Venter, Z. S., Barton, D. N., Gundersen, V., Figari, H., & Nowell, M. (2020). Urban nature in a time of crisis: Recreational use of green space increases during the COVID-19 outbreak in Oslo, Norway. *Environmental Research Letters*, 15(10), 104075.
- Ventriglio, A., Bellomo, A., di Gioia, I., Di Sabatino, D., Favale, D., De Berardis, D., & Cianconi, P. (2021). Environmental pollution and mental health: A narrative review of literature. *CNS Spectrums*, 26(1), Article 1. <https://doi.org/10.1017/S1092852920001303>
- Ventriglio, A., Torales, J., Castaldelli-Maia, J. M., De Berardis, D., & Bhugra, D. (2021). Urbanization and emerging mental health issues. *CNS Spectrums*, 26(1), Article 1. <https://doi.org/10.1017/S1092852920001236>

- Viera-Pérez, M., Hernández-Calvento, L., Hesp, P. A., & Santana-del Pino, A. (2019). Effects of artificial light on flowering of foredune vegetation. *Ecology*, 100(5), Article 5. <https://doi.org/10.1002/ecy.2678>
- Vultaggio, G. (2021). “*The Most Anxious Generation*”: The relationship between Gen Z students, social media, and anxiety. <http://hdl.handle.net/20.500.12648/1916>
- Walker, M. (2012). Navigating oceans and cultures: Polynesian and European navigation systems in the late eighteenth century. *Journal of the Royal Society of New Zealand*, 42(2, SI), Article 2, SI. <https://doi.org/10.1080/03036758.2012.673494>
- Walker, W. H., II, Walton, J. C., DeVries, A. C., & Nelson, R. J. (2020). Circadian rhythm disruption and mental health. *Translational Psychiatry*, 10(1), Article 1. <https://doi.org/10.1038/s41398-020-0694-0>
- Wang, T., Kaida, N., & Kaida, K. (2023). Effects of outdoor artificial light at night on human health and behavior: A literature review. *Environmental Pollution*, 323. <https://doi.org/10.1016/j.envpol.2023.121321>
- Weber, D., & Anderson, D. (2010). Contact with nature: Recreation experience preferences in Australian parks. *Annals of Leisure Research*, 13(1–2), 46–69.
- White, M. P., Alcock, I., Grellier, J., Wheeler, B. W., Hartig, T., Warber, S. L., Bone, A., Depledge, M. H., & Fleming, L. E. (2019). Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Scientific Reports*, 9(1), Article 1. <https://doi.org/10.1038/s41598-019-44097-3>
- Williamson, R. (n.d.). *Living the Sky: The Cosmos of the American Indian*.
- Williamson, R. A., & Farrer, C. R. (1994). *Earth and Sky: Visions of the Cosmos in Native American Folklore*. University of New Mexico Press. <https://books.google.com/books?id=IrNSPgAACAAJ>

- Witherington, B. E., & Bjorndal, K. A. (1991). Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles *Caretta caretta*. *Biological Conservation*, 55(2), 139–149.
- Yasuhiro, K., Su-Hie, T., & Neary, S. (2021). Mental health of Malaysian university students: UK comparison, and relationship between negative mental health attitudes, self-compassion, and resilience. *Higher Education*, 81(2), Article 2.
- Zajac, M., Warchoł, K., Borowiecka, M., & Brzezińska, A. (2021). Association between Artificial Light at Night Exposure and breast and prostate cancer risk—the review. *Journal of Education, Health and Sport*, 11(8), Article 8.
- Zelenski, J. M., & Nisbet, E. (2014). Happiness and Feeling Connected. *Environment and Behavior*, 46, 23–3.
- Zeman, M., Okuliarova, M., & Rumanova, V. S. (2023). Disturbances of Hormonal Circadian Rhythms by Light Pollution. *International Journal of Molecular Sciences*, 24(8). <https://doi.org/10.3390/ijms24087255>
- Zielinska-Dabkowska, K., Hanifin, J., & Brainard, G. (2023). Reducing nighttime light exposure in the urban environment to benefit human health and society. *Science*, 380(6650), Article 6650.

Appendix 3.1 Extent of lost ESV by country

The extent of loss of ESV from light pollution by country

Country	Population	Unpolluted ESV	LP Degraded ESV	Total Loss of ESV	% Loss of ESV	Per Capita Loss of ESV
Abyei	21,282,644	4,187,720,796	4,008,272,586	179,448,210	4.3	8
Afghanistan	38,588,032	148,177,666,077	142,219,060,293	5,958,605,784	4	154
Aksai Chin	21,282,644	2,537,106,902	2,537,106,902	0	0	0
Albania	2,793,717	13,752,013,408	11,280,729,240	2,471,284,168	18	885
Algeria	43,233,320	223,731,581,261	195,402,250,499	28,329,330,762	12.7	655
American Samoa	50,464	10,849,740	9,137,568	1,712,172	15.8	34
Andorra	76,766	193,466,848	146,968,031	46,498,817	24	606
Angola	32,591,274	721,224,609,459	704,835,987,176	16,388,622,283	2.3	503
Anguilla	12,010	80,109,302	65,967,777	14,141,525	17.7	1177
Antigua & Barbuda	89,660	766,557,857	682,801,076	83,756,781	10.9	934
Argentina	44,925,741	2,299,767,135,815	2,020,953,078,042	278,814,057,773	12.1	6206
Armenia	2,964,472	14,224,281,093	12,284,738,536	1,939,542,557	13.6	654
Aruba	105,009	98,756,749	72,203,222	26,553,527	26.9	253
Arunachal Pradesh	21,282,644	29,929,480,594	28,522,301,977	1,407,178,617	4.7	66
Australia	24,756,403	3,438,966,391,285	3,372,130,324,170	66,836,067,115	1.9	2700
Austria	8,997,211	36,799,816,392	29,265,732,872	7,534,083,520	20.5	837
Azerbaijan	10,074,935	145,639,543,052	129,074,503,916	16,565,039,136	11.4	1644
Azores Islands	9,772,405	1,090,921,098	942,063,848	148,857,250	13.6	15
Bahamas	289,720	46,503,459,465	43,897,160,613	2,606,298,852	5.6	8996
Bahrain	1,268,569	162,003,112	98,125,881	63,877,231	39.4	50
Bangladesh	162,702,799	113,466,659,460	95,607,633,778	17,859,025,682	15.7	110
Barbados	268,584	245,987,668	184,522,593	61,465,075	25	229
Belarus	9,458,805	165,939,018,780	146,387,169,440	19,551,849,340	11.8	2067
Belgium	11,597,050	15,626,679,487	10,411,668,814	5,215,010,673	33.4	450
Belize	377,287	44,942,828,003	40,359,950,531	4,582,877,472	10.2	12147
Benin	12,225,827	59,498,079,776	56,420,523,117	3,077,556,659	5.2	252
Bermuda	16,664	1,419,000	1,163,052	255,948	18	15
Bhutan	816,728	15,852,530,136	14,621,016,472	1,231,513,664	7.8	1508
Bolivia	11,666,700	882,738,140,919	855,294,590,684	27,443,550,235	3.1	2352
Bosnia & Herzegovina	3,275,135	21,344,986,618	17,372,339,503	3,972,647,115	18.6	1213
Botswana	2,342,311	355,257,382,953	347,939,904,320	7,317,478,633	2.1	3124
Bouvet Island	n/a	3,781,140	3,781,140	0	0	n/a
Brazil	208,631,258	5,910,799,506,600	5,514,990,167,080	395,809,339,520	6.7	1897

Country	Population	Unpolluted ESV	LP Degraded ESV	Total Loss of ESV	% Loss of ESV	Per Capita Loss of ESV
British Indian Ocean Territory	n/a	5,994,780	5,390,352	604,428	10.1	n/a
British Virgin Islands	26,720	84,125,793	73,606,334	10,519,459	12.5	394
Brunei Darussalam	405,418	3,370,084,666	2,717,505,577	652,579,089	19.4	1610
Bulgaria	6,875,240	53,707,986,960	44,491,049,398	9,216,937,562	17.2	1341
Burkina Faso	20,853,464	139,886,582,143	133,840,315,591	6,046,266,552	4.3	290
Burundi	11,950,557	18,253,829,615	17,332,159,288	921,670,327	5	77
Cambodia	16,565,006	116,703,294,410	108,344,347,752	8,358,946,658	7.2	505
Cameroon	26,333,514	311,784,285,979	301,452,482,511	10,331,803,468	3.3	392
Canada	37,089,067	5,740,884,713,588	4,739,411,500,910	1,001,473,212,678	17.4	27002
Cape Verde	481,089	3,920,509,366	3,528,651,111	391,858,255	10	815
Cayman Islands	49,018	879,174,144	704,593,223	174,580,921	19.9	3562
Central African Republic	4,772,164	237,018,983,511	236,767,938,175	251,045,336	0.1	53
Chad	16,519,566	442,148,111,433	439,019,560,197	3,128,551,236	0.7	189
Chile	18,562,983	237,718,075,393	217,323,637,678	20,394,437,715	8.6	1099
China	1,422,468,925	4,147,893,588,321	3,563,705,132,976	584,188,455,345	14.1	411
Christmas Island	1,884	8,211,060	7,692,960	518,100	6.3	275
Cocos (Keeling) Islands	28	1,187,340	1,158,399	28,941	2.4	1017
Colombia	50,359,369	855,936,999,472	793,275,193,856	62,661,805,616	7.3	1244
Comoros	775,990	1,278,561,711	1,225,922,789	52,638,922	4.1	68
Congo	5,533,711	207,471,578,664	201,937,408,955	5,534,169,709	2.7	1000
Cook Islands	9,630	9,951,480	9,722,922	228,558	2.3	24
Costa Rica	5,063,549	33,451,374,823	28,185,245,705	5,266,129,118	15.7	1040
Côte d'Ivoire	25,395,041	150,749,239,560	138,008,409,024	12,740,830,536	8.5	502
Croatia	3,845,537	25,766,949,780	20,254,408,440	5,512,541,340	21.4	1433
Cuba	11,052,702	172,836,830,514	155,289,307,775	17,547,522,739	10.2	1588
Cyprus	1,153,383	4,151,164,178	3,095,030,597	1,056,133,581	25.4	916
Czech Republic	10,716,424	38,713,291,230	28,833,574,374	9,879,716,856	25.5	922
Democratic People's Republic of Korea	25,030,964	57,332,040,145	53,908,318,971	3,423,721,174	6	137
Democratic Republic of the Congo	89,174,080	1,311,970,952,888	1,302,505,410,634	9,465,542,254	0.7	106
Denmark	5,333,128	28,632,104,042	23,346,433,010	5,285,671,032	18.5	991
Djibouti	799,829	2,001,310,783	1,895,575,535	105,735,248	5.3	132
Dominica	60,437	428,792,133	384,539,673	44,252,460	10.3	732

Country	Population	Unpolluted ESV	LP Degraded ESV	Total Loss of ESV	% Loss of ESV	Per Capita Loss of ESV
Dominican Republic	10,690,072	30,780,238,572	25,246,171,176	5,534,067,396	18	518
Ecuador	17,123,960	171,664,056,068	143,181,999,740	28,482,056,328	16.6	1663
Egypt	101,198,551	98,390,531,173	81,007,028,607	17,383,502,566	17.7	172
El Salvador	6,434,750	13,267,114,920	11,061,709,243	2,205,405,677	16.6	343
Equatorial Guinea	1,280,538	16,544,654,088	15,192,456,874	1,352,197,214	8.2	1056
Eritrea	3,367,840	31,635,658,216	31,008,795,378	626,862,838	2	186
Estonia	1,275,043	36,424,691,966	30,489,489,179	5,935,202,787	16.3	4655
Ethiopia	114,639,865	527,813,217,852	518,214,312,721	9,598,905,131	1.8	84
Falkland Islands (Malvinas)	3,383	5,529,311,522	5,473,358,403	55,953,119	1	16539
Faroe Islands	39,882	624,331,636	552,022,298	72,309,338	11.6	1813
Fiji	809,771	10,421,195,951	9,918,513,224	502,682,727	4.8	621
Finland	5,371,535	250,058,975,172	204,373,526,590	45,685,448,582	18.3	8505
France	64,164,786	268,814,413,916	208,730,501,790	60,083,912,126	22.4	936
French Guiana	254,140	51,091,158,464	49,776,110,151	1,315,048,313	2.6	5174
French Polynesia	189,121	138,001,380	128,795,799	9,205,581	6.7	49
French Southern and Antarctic Territories	n/a	492,055,080	492,055,080	0	0	n/a
Gabon	2,134,133	167,915,286,827	159,326,313,025	8,588,973,802	5.1	4025
Gambia	2,385,611	17,266,238,253	16,411,540,338	854,697,915	5	358
Gaza Strip	5,554,252	210,552,530	140,349,946	70,202,584	33.3	13
Georgia	3,907,322	30,533,516,235	25,892,140,703	4,641,375,532	15.2	1188
Germany	83,709,638	191,033,412,106	145,772,508,067	45,260,904,039	23.7	541
Ghana	30,921,654	147,397,974,753	132,808,234,168	14,589,740,585	9.9	472
Gibraltar	28,162	3,203,643	2,081,809	1,121,834	35	40
Glorioso Islands	21,282,644	12,591,910	12,591,910	0	0	0
Greece	9,833,693	57,843,909,511	46,073,633,861	11,770,275,650	20.3	1197
Greenland	31,602	47,223,327,514	33,125,703,012	14,097,624,502	29.9	446097
Grenada	99,893	195,273,495	167,091,847	28,181,648	14.4	282
Guadeloupe	366,283	995,925,614	770,962,591	224,963,023	22.6	614
Guam	164,283	38,154,600	28,740,360	9,414,240	24.7	57
Guantanamo	21,282,644	222,067,995	187,829,753	34,238,242	15.4	2
Guatemala	17,847,633	66,801,859,124	58,914,132,346	7,887,726,778	11.8	442
Guernsey	21,282,644	43,096,395	37,096,142	6,000,253	13.9	0
Guinea	13,104,454	127,122,992,938	122,438,982,249	4,684,010,689	3.7	357
Guinea-Bissau	1,930,797	37,471,322,732	36,305,032,325	1,166,290,407	3.1	604
Guyana	769,297	157,351,736,349	152,625,151,950	4,726,584,399	3	6144

Country	Population	Unpolluted ESV	LP Degraded ESV	Total Loss of ESV	% Loss of ESV	Per Capita Loss of ESV
Haiti	10,766,421	19,249,240,608	18,013,592,805	1,235,647,803	6.4	115
Hala'ib Triangle	21,282,644	895,993,610	882,414,257	13,579,353	1.5	1
Heard Island and McDonald Islands	n/a	26,306,280	24,841,641	1,464,639	5.6	n/a
Holy See	999	289,928	173,934	115,994	40	116
Honduras	9,748,921	114,953,223,750	107,737,750,381	7,215,473,369	6.3	740
Hong Kong	5,976,701	584,646,589	356,645,961	228,000,628	39	38
Hungary	9,650,496	55,573,528,665	44,298,226,275	11,275,302,390	20.3	1168
Iceland	294,149	44,802,017,490	38,704,365,186	6,097,652,304	13.6	20730
Ilemi Triangle	21,282,644	6,280,441,979	6,280,441,979	0	0	0
India	1,359,486,373	1,703,221,284,422	1,377,265,035,715	325,956,248,707	19.1	240
Indonesia	264,728,322	1,312,937,159,631	1,212,687,644,061	100,249,515,570	7.6	379
Iran (Islamic Republic of)	83,595,438	429,431,939,702	347,498,125,354	81,933,814,348	19.1	980
Iraq	40,245,748	150,705,282,766	108,276,032,306	42,429,250,460	28.2	1054
Ireland	4,789,216	33,789,942,377	27,686,856,213	6,103,086,164	18.1	1274
Isle of Man	81,454	280,311,668	244,293,315	36,018,353	12.8	442
Israel	8,129,680	6,528,998,533	4,240,341,203	2,288,657,330	35.1	282
Italy	58,962,803	139,285,932,706	98,880,681,839	40,405,250,867	29	685
Jamaica	2,826,805	7,492,798,286	5,948,797,175	1,544,001,111	20.6	546
Jammu- Kashmir	21,282,644	41,716,739,523	36,910,865,217	4,805,874,306	11.5	226
Japan	121,102,040	149,514,419,420	118,760,405,601	30,754,013,819	20.6	254
Jarvis Island	21,282,644	542,520	542,520	0	0	0
Jersey	21,282,644	65,860,723	54,427,994	11,432,729	17.4	1
Jordan	10,212,817	10,224,226,347	7,691,391,426	2,532,834,921	24.8	248
Kazakhstan	18,776,826	1,777,340,269,471	1,670,546,373,318	106,793,896,153	6	5688
Kenya	53,640,954	286,075,496,847	274,085,173,231	11,990,323,616	4.2	224
Kiribati	1,659	28,014,360	27,782,832	231,528	0.8	140
Kuril Islands	21,282,644	1,636,707,631	1,554,951,163	81,756,468	5	4
Kuwait	3,535,577	1,492,106,121	962,460,986	529,645,135	35.5	150
Kyrgyzstan	6,497,629	81,399,264,436	73,424,069,277	7,975,195,159	9.8	1227
Lao People's Democratic Republic	7,280,290	128,510,975,170	120,337,061,881	8,173,913,289	6.4	1123
Latvia	1,840,428	42,205,514,469	36,195,868,969	6,009,645,500	14.2	3265
Lebanon	6,608,762	4,543,081,043	3,142,107,493	1,400,973,550	30.8	212
Lesotho	2,129,217	14,316,492,389	13,242,462,497	1,074,029,892	7.5	504
Liberia	5,014,386	55,221,910,062	54,395,845,207	826,064,855	1.5	165
Libyan Arab Jamahiriya	6,812,471	114,112,449,481	104,580,302,219	9,532,147,262	8.4	1399
Liechtenstein	40,258	74,394,881	56,957,035	17,437,846	23.4	433

Country	Population	Unpolluted ESV	LP Degraded ESV	Total Loss of ESV	% Loss of ESV	Per Capita Loss of ESV
Lithuania	2,729,169	38,962,058,934	32,788,232,133	6,173,826,801	15.8	2262
Luxembourg	628,087	1,161,244,175	802,632,376	358,611,799	30.9	571
Macao	364,734	4,834,257	2,900,292	1,933,965	40	5
Madagascar	27,419,650	303,716,022,543	301,810,168,546	1,905,853,997	0.6	70
Madeira Islands	21,282,644	313,927,905	231,331,714	82,596,191	26.3	4
Malawi	19,137,241	94,464,047,135	89,722,163,949	4,741,883,186	5	248
Malaysia	31,177,346	183,656,508,122	158,719,024,359	24,937,483,763	13.6	800
Maldives	27,685	2,531,032	2,341,506	189,526	7.5	7
Mali	20,312,670	391,046,704,607	383,921,991,925	7,124,712,682	1.8	351
Malta	405,250	150,956,410	101,889,478	49,066,932	32.5	121
Marshall Islands	6,054	2,300,100	2,261,721	38,379	1.7	6
Martinique	353,132	665,832,805	491,437,198	174,395,607	26.2	494
Ma'tan al- Sarra	21,282,644	107,878,502	107,878,502	0	0	0
Mauritania	4,609,709	140,291,571,122	138,964,232,817	1,327,338,305	0.9	288
Mauritius	1,258,739	14,341,759,931	11,108,555,335	3,233,204,596	22.5	2569
Mayotte	221,269	231,048,572	194,715,246	36,333,326	15.7	164
Mexico	128,217,881	1,141,813,750,617	987,855,766,296	153,957,984,321	13.5	1201
Micronesia (Federated States of)	44,241	34,224,300	32,291,589	1,932,711	5.6	44
Midway Is.	21,282,644	217,140	217,140	0	0	0
Moldova, Republic of	3,998,870	21,255,035,905	18,317,718,428	2,937,317,477	13.8	735
Monaco	19,962	4,244,913	2,801,842	1,443,071	34	72
Mongolia	3,273,620	470,742,585,793	465,250,887,109	5,491,698,684	1.2	1678
Montenegro	599,444	6,304,419,318	5,134,900,360	1,169,518,958	18.6	1951
Montserrat	4,825	59,696,699	55,256,584	4,440,115	7.4	920
Morocco	36,420,455	116,637,985,490	97,916,779,091	18,721,206,399	16.1	514
Mozambique	30,899,707	472,085,447,671	456,790,631,660	15,294,816,011	3.2	495
Myanmar	53,512,284	395,446,335,823	368,256,113,522	27,190,222,301	6.9	508
Namibia	2,588,051	304,974,542,887	297,934,984,720	7,039,558,167	2.3	2720
Nauru	7,232	1,211,100	1,034,517	176,583	14.6	24
Nepal	29,527,792	60,496,070,362	54,972,195,802	5,523,874,560	9.1	187
Netherlands	16,864,681	26,866,768,483	18,189,188,617	8,677,579,866	32.3	515
Netherlands Antilles	180,091	489,922,041	387,972,175	101,949,866	20.8	566
New Caledonia	260,668	12,712,662,341	11,796,380,971	916,281,370	7.2	3515
New Zealand	4,532,583	141,003,110,734	131,761,953,127	9,241,157,607	6.6	2039
Nicaragua	6,562,166	170,837,689,481	163,308,695,592	7,528,993,889	4.4	1147
Niger	24,064,035	228,659,505,016	225,535,545,933	3,123,959,083	1.4	130

Country	Population	Unpolluted ESV	LP Degraded ESV	Total Loss of ESV	% Loss of ESV	Per Capita Loss of ESV
Nigeria	204,860,912	672,671,666,035	607,802,876,937	64,868,789,098	9.6	317
Niue	1,479	16,519,800	16,517,325	2,475	0	2
Norfolk Island	1,984	3,236,640	3,236,640	0	0	0
Northern Mariana Islands	48,375	15,702,720	13,293,951	2,408,769	15.3	50
Norway	4,678,407	135,787,068,455	111,789,284,064	23,997,784,391	17.7	5129
Oman	5,064,212	21,402,459,984	17,736,576,977	3,665,883,007	17.1	724
Pakistan	215,416,616	252,134,189,483	215,650,645,053	36,483,544,430	14.5	169
Palau	12,640	602,959,216	565,240,376	37,718,840	6.3	2984
Panama	4,209,605	49,526,360,682	44,121,473,618	5,404,887,064	10.9	1284
Papua New Guinea	8,295,017	314,620,224,793	310,759,981,159	3,860,243,634	1.2	465
Paracel Islands	21,282,644	1,350,851	1,349,168	1,683	0.1	0
Paraguay	7,099,836	450,206,720,997	408,005,135,371	42,201,585,626	9.4	5944
Peru	32,098,381	658,312,225,706	628,035,892,551	30,276,333,155	4.6	943
Philippines	101,183,399	192,778,899,231	173,499,997,493	19,278,901,738	10	191
Pitcairn Island	50	3,177,240	3,177,240	0	0	0
Poland	37,774,377	179,964,787,420	137,180,377,783	42,784,409,637	23.8	1133
Portugal	9,772,405	41,702,986,868	31,197,312,767	10,505,674,101	25.2	1075
Puerto Rico	2,818,699	6,175,821,177	4,314,801,220	1,861,019,957	30.1	660
Qatar	2,797,652	1,072,102,368	676,024,370	396,077,998	36.9	142
Republic of Korea	48,918,731	45,259,352,928	31,578,170,188	13,681,182,740	30.2	280
Reunion	831,109	5,444,594,109	4,350,327,699	1,094,266,410	20.1	1317
Romania	19,172,668	157,583,593,994	132,258,508,568	25,325,085,426	16.1	1321
Russian Federation	145,428,954	21,983,656,122,536	19,066,760,337,222	2,916,895,785,314	13.3	20057
Rwanda	13,151,503	22,014,810,506	20,074,466,769	1,940,343,737	8.8	148
Saint Kitts and Nevis	33,209	124,220,078	102,048,208	22,171,870	17.8	668
Saint Lucia	182,671	380,880,780	313,722,753	67,158,027	17.6	368
Saint Vincent and the Grenadines	81,173	199,816,512	175,700,764	24,115,748	12.1	297
Samoa	163,515	194,599,680	188,306,844	6,292,836	3.2	38
San Marino	30,907	26,852,889	17,994,824	8,858,065	33	287
Sao Tome and Principe	207,500	1,296,825,303	1,210,793,157	86,032,146	6.6	415
Saudi Arabia	34,103,513	137,465,575,618	114,783,156,322	22,682,419,296	16.5	665
Senegal	16,526,508	125,661,548,258	119,993,320,729	5,668,227,529	4.5	343
Serbia	8,728,494	41,791,480,421	31,749,514,141	10,041,966,280	24	1150
Seychelles	78,849	265,440,714	262,995,348	2,445,366	0.9	31
Sierra Leone	7,857,163	55,170,126,145	53,643,612,291	1,526,513,854	2.8	194
Singapore	5,460,772	342,144,827	205,266,997	136,877,830	40	25

Country	Population	Unpolluted ESV	LP Degraded ESV	Total Loss of ESV	% Loss of ESV	Per Capita Loss of ESV
Slovakia	5,462,853	22,577,215,438	17,786,095,751	4,791,119,687	21.2	877
Slovenia	2,074,760	8,248,742,978	6,380,271,654	1,868,471,324	22.7	901
Solomon Islands	441,418	15,181,674,981	15,062,570,127	119,104,854	0.8	270
Somalia	15,798,916	220,600,979,615	219,402,499,773	1,198,479,842	0.5	76
South Africa	59,063,032	511,647,196,988	458,250,006,816	53,397,190,172	10.4	904
S. Georgia & the S. Sandwich Islands	21,282,644	244,328,040	244,328,040	0	0	0
South Sudan	11,107,471	616,636,228,278	615,210,181,379	1,426,046,899	0.2	128
Spain	45,427,397	238,029,730,296	186,252,787,300	51,776,942,996	21.8	1140
Spratly Islands	21,282,644	280,500	280,500	0	0	0
Sri Lanka	20,894,086	39,949,044,545	35,317,522,491	4,631,522,054	11.6	222
Sudan	43,836,202	432,218,968,793	419,429,374,737	12,789,594,056	3	292
Suriname	575,438	104,647,269,627	100,933,841,534	3,713,428,093	3.5	6453
Svalbard and Jan Mayen Islands	2,677	3,390,376,093	100,415,333	3,289,960,760	97	1229003
Swaziland	1,152,414	7,992,693,174	6,913,927,895	1,078,765,279	13.5	936
Sweden	9,299,703	222,643,695,626	186,580,885,412	36,062,810,214	16.2	3878
Switzerland	8,677,515	17,695,459,495	13,387,569,765	4,307,889,730	24.3	496
Syrian Arab Republic	17,541,255	66,851,366,079	56,045,518,478	10,805,847,601	16.2	616
Taiwan	23,168,025	24,861,152,572	17,500,362,427	7,360,790,145	29.6	318
Tajikistan	9,507,897	42,770,106,211	38,356,965,655	4,413,140,556	10.3	464
Thailand	69,293,408	323,586,184,454	266,760,228,800	56,825,955,654	17.6	820
The former Yugoslav Republic of Macedonia	2,097,688	11,079,797,328	9,064,296,073	2,015,501,255	18.2	961
Timor-Leste	1,236,450	8,672,138,897	8,156,298,307	515,840,590	5.9	417
Togo	8,255,852	29,576,381,436	27,624,618,166	1,951,763,270	6.6	236
Tokelau	389	489,720	489,720	0	0	0
Tonga	55,397	630,158,717	551,900,127	78,258,590	12.4	1413
Trinidad and Tobago	1,311,000	3,009,910,620	2,078,535,197	931,375,423	30.9	710
Tunisia	11,195,361	39,437,314,798	32,007,942,523	7,429,372,275	18.8	664
Turkey	82,320,710	360,270,755,985	282,483,182,519	77,787,573,466	21.6	945
Turkmenistan	6,236,771	243,989,367,809	220,015,462,657	23,973,905,152	9.8	3844
Turks and Caicos Islands	6,178	506,948,764	467,734,301	39,214,463	7.7	6347
Tuvalu	n/a	1,919,280	1,854,501	64,779	3.4	n/a

Country	Population	Unpolluted ESV	LP Degraded ESV	Total Loss of ESV	% Loss of ESV	Per Capita Loss of ESV
U.K. of Great Britain and Northern Ireland	66,440,468	123,760,363,942	95,810,444,048	27,949,919,894	22.6	421
Uganda	45,931,527	221,014,845,179	211,484,217,162	9,530,628,017	4.3	207
Ukraine	43,406,455	457,992,639,490	395,147,891,014	62,844,748,476	13.7	1448
United Arab Emirates	9,406,788	5,777,947,043	4,088,923,293	1,689,023,750	29.2	180
United Republic of Tanzania	59,371,515	575,097,568,150	559,763,778,017	15,333,790,133	2.7	258
United States of America	325,446,306	6,660,740,456,992	5,450,293,924,564	1,210,446,532,428	18.2	3719
US Virgin Islands	92,791	218,753,345	165,732,051	53,021,294	24.2	571
Uruguay	3,477,234	132,894,788,770	118,815,824,138	14,078,964,632	10.6	4049
Uzbekistan	33,529,243	194,773,276,270	176,775,712,140	17,997,564,130	9.2	537
Vanuatu	219,800	7,887,640,146	7,806,407,363	81,232,783	1	370
Venezuela	27,789,099	822,512,077,445	753,710,958,411	68,801,119,034	8.4	2476
Vietnam	94,692,676	248,248,290,695	206,793,517,005	41,454,773,690	16.7	438
West Bank	5,554,252	2,607,779,328	1,652,573,687	955,205,641	36.6	172
Western Sahara	509,955	17,390,488,831	17,125,731,177	264,757,654	1.5	519
Yemen	29,380,384	52,778,011,580	49,010,211,639	3,767,799,941	7.1	128
Zambia	18,472,190	607,520,499,806	591,211,068,167	16,309,431,639	2.7	883
Zimbabwe	14,868,701	179,252,098,712	171,854,943,250	7,397,155,462	4.1	497

Appendix 4.1 Lighting Ordinance



Dark Sky Lighting Policy - Carrickalinga

Strategic Reference	Provide leadership, good governance, and efficient, effective and responsive Council services
File Reference / Record No	18/067/229 /NGO223073
Responsibility	Operations
Version Number	2.0
Last Revised Date	December 2022
Minute Book Reference	C22268
Next Review Date	December 2024
Applicable Legislation	Local Government Act 1999; Planning, Development and Infrastructure Act, 2016 Australian Standards; Electricity Act 1996
Related Policies	Nil
Related Procedures / Documents	SA Power Networks Technical Standard - TS101 International Dark Sky Community Program Guidelines 2018 Manual of Legal Responsibilities and technical Requirements for Traffic Control Devices

1. Objective

- 1.1. The District Council of Yankalilla recognises the uniqueness and opportunities available to communities within the district to seek recognition from the International Dark-Sky Association as an International Dark Sky Community. This is the case given the limited existing lighting infrastructure within the semi-rural environment and coastal townships, together with the shelter provided from suburban light spill by the hills throughout the district.
- 1.2. The International Dark-Sky Association encourages outdoor lighting practices that will minimise light pollution, glare, light trespass, and sky glow in order to preserve the natural dark of the night sky, prevent lighting nuisances on properties and reduce

artificial light effects on wildlife. While maintaining the rural atmosphere and village character of the town and district.

Council under this Dark Sky Lighting policy for Carrickalinga aims to;

- 1.2.1. Ensure that Council, other Government bodies and private landholders within an area designated or seeking accreditation as an International Dark Sky Community, understands how they can assist attaining, preserving, and promoting the International Dark Sky Community concept.
- 1.2.2. Ensure all new public lighting within an area designated or seeking accreditation as an International Dark Sky Community, meets the standards and requirements expected by the International Dark Sky Association.
- 1.2.3. Retrofit existing outdoor public lighting within an area designated or seeking accreditation as an International Dark Sky Community, meets the standards and requirements expected by the International Dark-Sky Association.
- 1.2.4. Confirm that the costs for delivery of infrastructure works are to be borne by the groups requesting the Dark Sky infrastructure.

2. Scope

- 2.1. This policy shall only apply to the Designated Area of Carrickalinga Township, while actively seeking or where accreditation has been gained from the International Dark-Sky Association as an International Dark Sky Community. (Note: this Policy can be updated to apply via a further Council Resolution to other areas pending a process which is to include Public Consultation on an updated Draft)

3. Definition

- 3.1. For the purpose of this Policy, certain words, phrases and terms used herein shall have the meanings assigned to them by this section:
- 3.2. DESIGNATED AREA OF CARRICKALINGA TOWNSHIP: The area of Carrickalinga, which, in the views of a reasonable person, has the look and feel of a predominantly residential township area; generally located in the 'Neighbourhood Zone' as referenced in the Planning & Design Code.
- 3.3. CORRELATED COLOR TEMPERATURE (CCT): A specification of the colour appearance of the light emitted by a lamp, relating its colour to the colour of light from a reference source when heated to a particular temperature, measured in degrees kelvin (K).
- 3.4. DIRECT ILLUMINATION: Illumination resulting from light emitted directly from a lamp, luminary or reflector. This does not include light reflected from other surfaces, such as the ground or building faces.
- 3.5. INTERNATIONAL DARK SKY COMMUNITY: An International Dark Sky Community (IDSC) is a town, city, municipality or other similar political entity that has shown exceptional dedication to the preservation of the night sky through the implementation

and enforcement of quality lighting policies, dark-sky education, and citizen support of the ideal of dark skies.

- 3.6. **FLOODLIGHT:** A fixture or lamp designed to "flood" an area with light. A specific form of lamp or fixture designed to direct its output in a specific direction. Such lamps are often designated by the manufacturer and are commonly used in residential outdoor lighting. These lights should not emit light above the 45 degree plane and they do not exceed 1,000 lumens
- 3.7. **FULLY SHEILDED:** An outdoor light fixture designed so that the installed fixture emits no light above the horizontal plane of the lowest part of the fixture. These light fixtures must be shielded in and of themselves. Surrounding structures, like canopies, are not to be considered when determining if the fixture is full cut off Fully Sheilded fixtures must be appropriately mounted so that the shielding prevents light from escaping above the horizontal and all light is directed downward.
- 3.8. **LIGHT POLLUTION:** Any adverse effect of non-natural light sources. Often used to denote "sky glow" from cities or towns, but also includes glare, light trespass, visual clutter and other adverse effects of lighting.
- 3.9. **LIGHT SOURCE:** The part of a lighting fixture that produces light, e.g., the bulb.
- 3.10. **LIGHT TRESPASS:** Light falling where it is not wanted or needed. Spill light falling over property lines that illuminates adjacent grounds or buildings in an objectionable manner.
- 3.11. **LUMINAIRE:** a complete electric light unit.
- 3.12. **OUTDOOR LIGHT FIXTURE:** An outdoor electrically powered illuminating lamp or similar device used for lighting structures, parking lots, pathways, service canopies, recreational areas, signs or other similar outdoor lighting uses.
- 3.13. **RECREATIONAL LIGHTING:** Lighting used to illuminate sports fields, ball courts, playgrounds or similar outdoor recreational facilities.
- 3.14. **SPOTLIGHT:** A fixture or lamp designed to light a small area very brightly. See definition of Floodlight.
- 3.15. **UNSHIELDED FIXTURE:** A fixture that allows light to be emitted above the horizontal either directly from the lamp or indirectly from the fixture or reflector. Any fixture not full cut off.

4. Policy Statement

- 4.1. The District Council of Yankalilla recognises the uniqueness and opportunities available to communities within the district to seek recognition in the form of accreditation as an International Dark Sky Community. Given the opportunities for various communities to seek this recognition and the complex tenure arrangements (possibility of many hundreds of privately owned parcels of land) within these areas, it is proposed that management of lighting within areas designated or seeking accreditation as International Dark Sky Communities, is considered as two parts.

- 4.2. Public lighting infrastructure: being lighting infrastructure owned/ managed by Council, government bodies and/or other service authorities for the purpose of lighting public spaces and infrastructure.
- 4.3. Private infrastructure: focusing on community education, with private landowners being encouraged to upgrade existing external lights to be compliant with the International Dark Sky standards for International Dark Sky Communities.

5. Policy

New Public Infrastructure

- 5.1. If meeting all requirements under Australian standards and/ or other local authority standards, installation of all new Council managed outdoor public lighting shall be in accordance with the minimum requirements for lighting under International Dark Sky Community Program Guidelines June 2018.
- 5.2. Where possible, Lighting shall be 'Dark Sky Friendly' by considering the following principles;
 - Outdoor public lighting should only be installed when deemed necessary and should only be activated when needed
 - All outdoor lighting should be directed downwards so that light trespass is avoided
 - Fittings should include light shields so that light it is directed downwards and there is no upward lighting
 - The intensity of outdoor lighting should be appropriate for its intended use
 - Correlated colour temperature (CCT) of lighting shall be less than 3000 K. preferably 2200K

Public Street lighting

- 5.3. The District Council of Yankalilla specify the lowest lighting level category, as indicated in current Australian Standards, to keep the lighting level (and tariff costs) as low as possible; whilst recognising Council's obligations around crime prevention through environmental design (CPTED).
- 5.4. Installation of all new public street lighting will be to the minimum specifications in accordance with current Australian standards and utilising standard SA Power Networks luminaires which meet colour temperature requirements under International Dark Sky Community Program Guidelines (June 2018).
- 5.5. For all new street lighting installations shielding and/ or aero screen fittings shall be utilised as standard.
- 5.6. Layout for new street lighting shall be prepared by a suitably qualified lighting engineer, ensuring that lighting is minimised while still maintaining minimum standards required under Australian standards.

Private Development

- 5.7. Lighting plans must be prepared and provided for any new Development Applications that will lead to the development of new external lighting (public or private), this includes land division applications which require street lighting and commercial or residential developments where lighting is proposed (for example in car park areas or around buildings). Outdoor lighting plans shall be assessed against lighting principles in the 'International Dark Sky Community Program Guidelines (June 2018)', as well as relevant industry and Australian standards. To the extent that this Policy can require, those costs are to be borne by the developer.

Existing Infrastructure

- 5.8. Council recognises that existing luminaires and public lighting infrastructure may not meet the requirements for lighting under the 'International Dark Sky Community Program Guidelines (June 2018)'. In these cases, Council will work with communities seeking Dark Sky accreditation to prepare a lighting replacement plan to ensure that public lighting conforms with Dark Sky Standards (as well as current Australian standards) within a timeframe of no more than 5 years from official recognition of the area as a Dark Sky Community. These works are to be funded by the relevant community or community interest group who puts forward the request/ application for accreditation.
- 5.9. The District Council of Yankalilla commits to ensuring Dark Sky appropriate lighting will be designed and located accordingly when renewing or upgrading Council owned lighting within an area which has sought (or has received) accreditation.

Restricted lighting

- 5.10. To the extent to which this can be controlled through Legislation, Regulation, or through Council's own projects, the following lighting is to be restricted or prohibited within areas covered under this policy;
- Lighting which is directed towards the sky (unless required for safety reasons).
 - The use of searchlights, except when used by emergency personnel.
 - Lighting on advertisement signage is prohibited, except where it can be demonstrated that it meets the principles of 'Dark Sky Friendly Lighting'

6. Further Information

This policy will be available for inspection at the Council office listed below during ordinary business hours and provided to interested parties as per Council's Fees and Charges Register. Copies are available to be downloaded, free of charge, from Council's website: www.yankalilla.sa.gov.au/policies

District Council of Yankalilla
1 Charles Street
Yankalilla 5203

Phone: (08) 8558 0200

Fax: (08) 8558 2022

Email: council@yankalilla.sa.gov.au

Office hours: Monday to Friday, 9.00am to 5.00pm (except public holidays)

Page 5 of 6

Note: electronic version in the Synergy Records Management System is the controlled version. Printed copies are considered uncontrolled. Before using a printed copy as reference, verify that it is the current version.

YANKALILLA

7. Grievances

Any grievances in relation to this policy or its application should be forwarded in writing addressed to the Chief Executive Officer of Council.

8. Review Cycle

This document is subject to review in two (2) years from the date of authorisation.

9. Document History

Date	Version	Council Resolution No.	Description of changes
	1.0	C	Adoption of Policy
12/12/2022	1.1		Review of Policy – amendments provided by Sharolyn Anderson & Ashley Wilson of CRA

Appendix 4.2 Carrickalinga International Dark Sky Association Community Application

Application to the International Dark Sky Association for
Dark Sky Community Designation
for
Carrickalinga
District Council of Yankalilla, South Australia, Australia



Submitted by the Carrickalinga Dark Sky Committee

Following the 2018 IDSC Guidelines

Amy Gebhardt, President, Carrickalinga Ratepayers Association
Kim Baker, former President, Carrickalinga Ratepayer Association
Sheryn Pitman, Chair, Carrickalinga South Environment Group
Professor Chris Daniels, Resident
Sharolyn Anderson, Point of Contact for DarkSky application

Table of Contents

Section 1: Introduction	3
Request for Dark Sky Designation from Carrickalinga Ratepayers Association.....	3
Official Letter of Support from Mayor of Yankalilla Council	4
Final Letter of Support and Passage of Dark Sky Policy Adoption for Carrickalinga.....	5
Letter of Nomination from IDA Member- Marnie Ogg.....	7
Section 2: Introduction to Carrickalinga	8
History of the Town, Population and Location	8
Carrickalinga Area Boundary Map (Cadastral Map)	13
Town Boundary Map (Satellite View)	13
Carrickalinga night sky: Overview of General Condition	14
Section 3: Outdoor Lighting Ordinance	16
History of Lighting in Carrickalinga	16
2022 Dark Sky Lighting Ordinance	17
Section 4: Community Outreach.....	18
Community Events.....	18
Media	24
Section 5: Monitoring and Data Collection.....	27
Procedure (Current).....	27
Procedure (Proposed Monitoring).....	27
Section 6: Community Support.....	29
Section 7: Lighting Management Plan	33
Section 8: Carrickalinga Five Year Activity Plan	35
Appendix A: Letters of Support and Signed Support Documents.....	A-1
Appendix B: Dark Sky Lighting Policy – Carrickalinga	B-1
Appendix C: SQM Raw Data Collection.....	C-1
Appendix D: Survey results for UniSA’s Aboriginal Astronomy course	D-1
Appendix E: Survey results from the Farmer’s Market in Normanville	E-1
Appendix F: District Council of Yankalilla Report.....	F-1
Appendix G: Consultations Resources for Residents	G-1
Appendix H: Carrickalinga Streetlights.....	H-1
Appendix I: Greenhill Lighting Designers for Carrickalinga Streetlight Upgrade	I-1

Section 1: Introduction

Request for Dark Sky Designation from Carrickalinga Ratepayers Association



25th September 2022.

Dear International Dark Sky Association

5049 E Broadway Blvd, #105 Tucson, AZ 85711

In our application to become a Dark Sky Community, the local body (the Applicant), the Carrickalinga Ratepayers Association (CRA) will be responsible for creating a website to promote **Carrickalinga, the first International Dark Sky Community in Australia.**

The application has been campaigned by Sharolyn Anderson (Ph.D Data Scientist, Crawford School of Public Policy, The Australian National University).

The Carrickalinga community is fully supportive of this initiative and as such, CRA members have contributed funding towards its fulfilment.

A *Notice of Motion* was passed at the local Council (Yankalilla District Council) meeting Tuesday 21st June 2022 and their letter of support is attached.

As background to the IDA application: The Carrickalinga community is an ideal candidate for becoming an International Dark Sky Community. It is unique in that it is one of very few accessible, urbanised places that does not contain traditional street lighting. Australia has one International Dark Sky reserve (River Murray) and an International Dark Sky Park (Warrumbungle National Park); however, as of now, there are no International Dark Sky Communities in Australia. **Carrickalinga is therefore the ideal candidate to be the first International Dark Sky Community in Australia.**

The website promoting the **Carrickalinga, International Dark Sky Community** will be centred around DSC. It will co-exist under the carrickalinga.com.au domain name as we are promoting Carrickalinga as the designation and destination for DSC.

Anyone that searches for "Carrickalinga - Australia's Dark Sky Community", it will open as carrickalinga.com.au.

carrickalinga.com.au is a valuable domain name in its own right.

The CRA looks forward to working with the International Dark Sky Association in promoting dark sky communities across the world.

Yours faithfully

Kim Baker

A handwritten signature in blue ink, appearing to read 'Sharolyn Anderson', is written over a horizontal line.

President - Carrickalinga Ratepayers Association
M +61 411 862 978 PO Box 2162, Normanville SA 5204
CC Sharolyn Anderson

Official Letter of Support from Mayor of Yankalilla Council

District Council
of Yankalilla

22 June 2022



Doc Ref: NOCE221601
File Ref: 9/025/854

The International Dark Sky Places Program Manager
C/- The Carrickalinga Ratepayers Association
PO Box 2162
NORMANVILLE SA 5204

Dear International Dark Sky Places Program Manager

Letter of Support: Carrickalinga – Australia's First Dark Sky Community

Following ongoing discussions and engagement with the Carrickalinga Ratepayers Association in relation to the benefits of International Dark Skies Communities and the opportunity to support the application for Carrickalinga to be Australia's first Dark Sky Community, the District Council of Yankalilla, at its meeting on Tuesday, 22 June 2022 resolved:

1. That Council writes a letter providing in principle support for the Carrickalinga - Australia's First Dark Sky Community application.
2. That Council notes that the Carrickalinga Rate Payers Association will be responsible for lodging the application.
3. That Council notes that the Carrickalinga Rate Payers Association will be responsible for all activities required to receive a Dark Skies Communities Accreditation, including the cost of installation of light shields, and working with Council on the development of a Lighting Policy.
4. That Administration prepare a Lighting Policy for the Carrickalinga township in accordance with the "International Dark Sky Community Program Guidelines June 2018" and that this be brought back to Council for endorsement before proceeding to community consultation.

Council looks forward to seeing this initiative progress in our community and acknowledge the work of the Carrickalinga Ratepayers Association to make it happen.

Yours sincerely

A handwritten signature in blue ink, appearing to read "Simon Rothwell".

Simon Rothwell
Mayor

1 Charles Street
(PO Box 9)
Yankalilla SA 5203
yankalilla.sa.gov.au

Phone (08) 8558 0200
Fax (08) 8558 2022
Email council@yankalilla.sa.gov.au
ABN 17 163 010 167

YANKALILLA

Final Letter of Support and Passage of Dark Sky Policy Adoption for Carrickalinga

District Council
of Yankalilla

23 December 2022



DOC: NGO223067
File Ref: 9/025/854

International Dark Sky Places Program Manager
C/- The Carrickalinga Ratepayers Association
PO Box 2162
NORMANVILLE SA 5204

Dear International Dark Sky Places Program Manager

Dark Sky Policy Adoption by District Council of Yankalilla

Please be advised that a report was presented at the District Council of Yankalilla's Ordinary Council meeting on 20 December 2022 and Council resolved the following:

14.4 Dark Sky Community Consultation

*C22268 Moved Cr. Quirke
Seconded Cr. Verwey*

1. *That the Report be received.*
2. *That Council note the results of the Community Engagement Report provided at Attachment F of this report.*
3. *That Council endorse the Dark Sky Lighting - Carrickalinga Policy, as amended in response to consultation feedback and as provided at Attachment B of this report, with minor administrative amendments (if any) delegated to the Chief Executive Officer.*
4. *That Council confirms its support through preparing a letter for the Carrickalinga Ratepayers Association's (CRA) application to become a Dark Sky Community accredited by the International Dark-Sky Association.*
5. *That Council provides a copy of the survey results directly to the Carrickalinga Ratepayers Association (CRA).*

CARRIED Unanimously

Please the attached documents supplied to Council as part of their consideration. Survey results from the community engagement activities are identified in attachment F (Dark Sky Carrickalinga Community Engagement Report).

1 Charles Street
PO Box 98
Yankalilla SA 5203
yankalilla.sa.gov.au

Phone (08) 8558 0200
Fax (08) 8558 2022
Email council@yankalilla.sa.gov.au
ABN 17 163 010 187

YANKALILLA


District Council
of Yankalilla



Council is excited to be in a position to support this wonderful initiative and should you require any further information, please don't hesitate to contact me on nathan.cunningham@yankalilla.sa.gov.au or (08) 8558 0200.

Yours sincerely



Nathan Cunningham
Chief Executive Officer

Enc

1 Charles Street
(PO Box 9)
Yankalilla SA 5203
yankalilla.sa.gov.au

Phone (08) 8558 0200
Fax (08) 8558 0222
Email council@yankalilla.sa.gov.au
ABN 17 163 010 187


YANKALILLA


Letter of Nomination from IDA Member- Marnie Ogg



13 FEB 2022

Dear International Dark Sky Association Dark Sky Places Committee,

It is with much joy that I write in support of the nomination for Carrickalinga to be designated as Australia's First Dark Sky Community.

This popular holiday destination brings travellers from far across Australia, in pursuit of its white sandy beach, crystal clear waters and tantalising rock pools. Voted in 2013 by Lonely Planet as South Australia's most beautiful Beach, this provides a daytime activity that should be perfectly paired with nighttime experiences.

Whilst the town is placed on one of Australia's most iconic places, the Fleurier Peninsular, what makes this community an ideal candidate for Dark Sky Community status is the deep support that the community has shown in preserving this pristine environment – both day and night. The IDA designation would provide suitable recognition for the community commitment in putting together a 10-year plan that features conservation of the night sky.

I very much look forward to hearing of this sites success in achieving Dark Sky Community Status with the IDA and welcome any questions in the meantime.

Kind Regards.

A handwritten signature in black ink, appearing to read 'M. Ogg'.

Marnie Ogg
0417 689 003
Founding Director
Australasian Dark Sky Alliance

Section 2 Introduction to Carrickalinga

History of the Town, Population and Location



The Town of Carrickalinga

Carrickalinga (from Kurna language Karragadlangga) is a small coastal town in the District of Yankalilla, South Australia, about 70 kilometres south of Adelaide on the Fleurieu Peninsula overlooking Gulf St Vincent.

The Traditional Owners of this area are the Kurna and Ramindjeri People. The Tjilbruke Dreaming Track, based on the story of the journey of Tjilbruke, a Kurna ancestor, follows the Fleurieu Peninsula coastline. There is a plaque commemorating Tjilbruke on the foreshore at Carrickalinga South.

The town is currently made up of a community of permanent residents and holiday makers, with the nearest shops in Normanville, a few kilometres away. The majority of people live close to the two beaches, sometimes referred to as Carrickalinga North and Carrickalinga South, which are lightly separated by the rocky outcrop and hill of Haycock Point. A jetty was constructed at the point in 1923 but was later demolished due to exposure to wind and sea swell.

During the 2016 census (the latest currently available), Carrickalinga had a resident population of 364. However this can swell on weekends and during holidays, reaching thousands in the summer months. It is a popular holiday retreat for tourists far and wide, many attracted by the white sandy beaches, crystal clear waters, rock pools and wonderful views of sea and sunset. Some parts of the beach are also popular for fishing, with small boat launching facilities at Normanville not far away. Carrickalinga has been named as South Australia's best beach by Lonely Planet and others on more than one occasion.

Carrickalinga Heads at the northern end are described in geological terms as of "*Olive-green lithic sst. with thin shale interbeds; fining upwards to thin siltstones. Has significantly eroded Heatherdale Shale below in some areas*" (<https://asud.ga.gov.au/search-stratigraphic-units/results/25836>). They were formed in Botomian Age (517-510 million years ago).



The Carrickalinga Land System is a flat to gently undulating coastal plain. The land is underlain by alluvial sandy clays and clays derived from the rock ranges which flank the eastern side of the system. Abutting the ranges and superimposed on the alluvial sediments are drift sand banks, a metre or more deep. There is a relict deposit of glacial valley sediments in the north

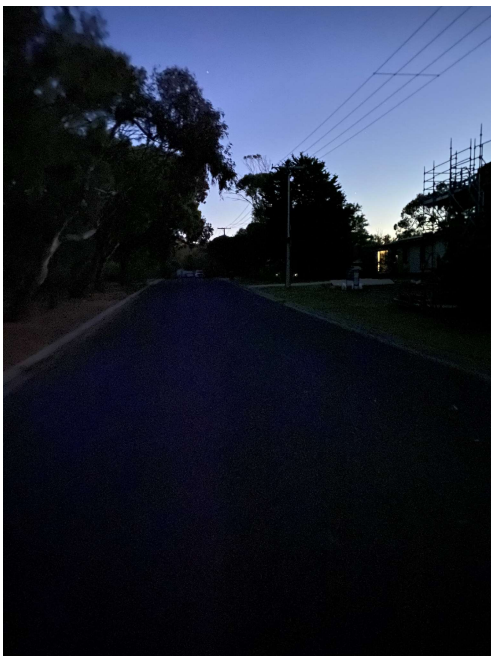
(<https://data.environment.sa.gov.au/Content/Land-System-reports/CAK.pdf>).



Alunite was discovered at Carrickalinga Heads in 1913, and mining began there in 1914. Adits, shafts and open cut mining were used to extract the Alunite, which was sent for processing from the Normanville Jetty. Mining ceased in 1915 due to the outbreak of WWI, but resumed in 1916 until the mine closed in 1919 due to increased costs.

The Normanville sand dunes extend into Carrickalinga, and are estimated to be at least 5,000 years old. They represent the last major remnants of dunes that once existed along the coast of Gulf St Vincent. The silica or quartz content of the sand is unusually high for South Australian dunes and is particularly suitable for the manufacture of glass. Between 1969 and 1988 the northern section of the dunes were mined by Australian Consolidated Industries (ACI). As a result these dunes are vulnerable to erosion due to loss of sand and vegetation. The Normanville Dunes are now recognised as a geological monument of national heritage significance and were listed on the State Heritage Register on 11 April 1996.

The Carrickalinga Creek cuts through the Normanville Dunes and flows into the sea on the southern edge of the town, although is usually blocked by sand in summer due to low seasonal rainfall and agricultural damming of the creek further up the catchment.



The name Carrickalinga first appeared in 1958 as the name of a private subdivision developed by a Gorge Lewis of Waterloo Corner in a cadastral unit of the Hundred of Myponga. Boundaries were established in respect to the Geographical Names Act 1988, with a portion being added in 1994 and then refined in 1999.

When the town was established the roads were unsealed and without curbs or streetlights. Over time the roads have been [bituminised](#), although most still do not have curbs. To this day there are very few streetlights in the town of Carrickalinga. The residents of Carrickalinga are generally happy with this situation – they like the relative lack of urbanisation and the darkness at night. The stars of the Milky Way are bright whenever there is no cloud cover.



Carrickalinga is home to a rich diversity of native flora and fauna. The creek, estuary and surrounding wetlands and dunes are inhabited by numerous birds including several migratory species. From the larger Wedge-tailed Eagles, White-breasted Sea Eagles, pelicans, swans and owls to falcons and hawks, cormorants and herons, magpies and ravens, lapwings and wattle birds to fantails and honeyeaters, quails and wrens, ducks and swallows, the birdlife is always abundant. The endangered beach-nesting Hooded Plovers inhabit the beach from the low tide line into the fore dunes, and occasionally have successful breeding attempts despite their many challenges.

Lizards and snakes, echidnas and microbats, frogs and numerous insects shelter, bask, dig, fly, pollinate or swim. Dolphins are long-term inhabitants of the local seas along with many species of fish and shark, molluscs and crustaceans. Sometimes whales and sea turtles visit the waters of Carrickalinga on their annual migration journeys.

The Leafy Seadragon, South Australia's marine emblem, along with other seadragons, pipefish and seahorses can be found in waters around jetty pylons and reefs, and are frequently spotted by fortunate divers and snorkelers.

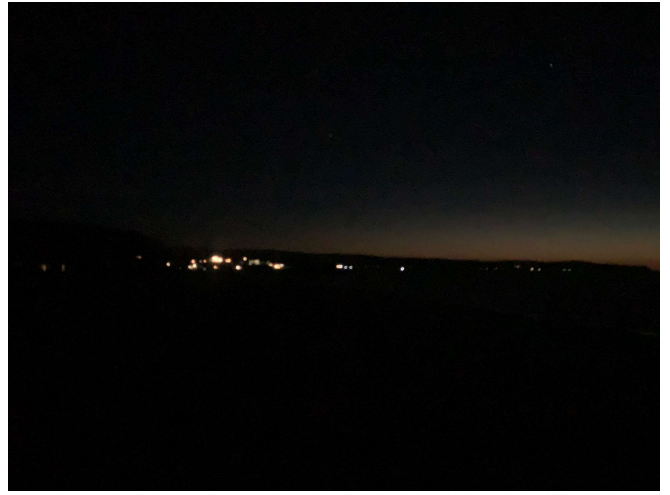
The Kurna language name for Carrickalinga (Karragadlangga) means red gum fire wood place and some beautiful great red gums remain today close to creeks and water holes. The vegetated coastal dunes are bound by a suite of well-adapted local native plants including trees and shrubs, herbs and groundcovers, grasses and sedges, all providing critical habitat for the wildlife. Residents are encouraged to plant local native plants in gardens to help provide the food and shelter the wildlife requires and to ensure that invasive plants don't escape into the dunes and creeks.

The cultural history of the Fleurieu Peninsula itself goes back many thousands of years and is documented in the rich oral traditions of the Kurna, Ramindjeri, Peramangk and Ngarrindjeri peoples. In 1802 the English navigator, Matthew Flinders and French explorer, Nicholas Baudin mapped the southern coast of Australia. They met close to the mouth of the River Murray and exchanged maps and information. Baudin named the region after the French wanderer, Charles Pierre Claret, Comte de Fleurieu. On 8th September, 1936, Colonel William Light first landed in South Australia at a place he named Rapid Bay. The first non-indigenous inhabitants of the area were fishermen, whalers and sealers. Land releases for farming quickly led to sheep, wheat, barley and other grain and vegetable crops, followed by dairy farming and some mining and timber milling.

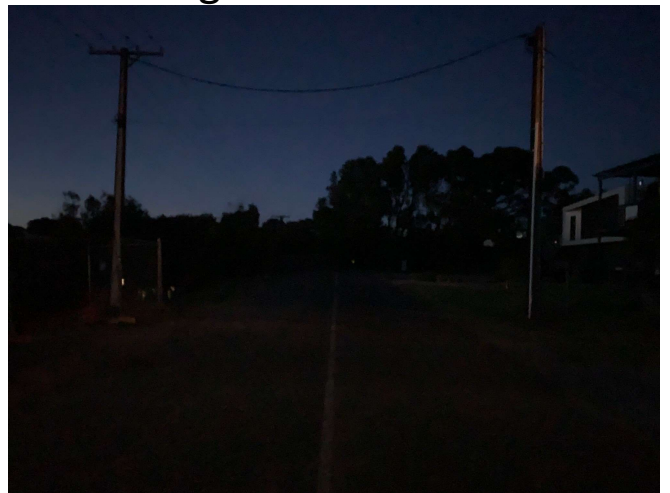
Carrickalinga At Night



Looking across Carrickalinga
South from C. Rise



Carrickalinga Head back towards
Carrickalinga



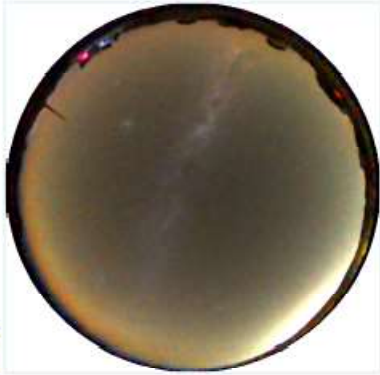
At street level – Carrickalinga Streets few streetlights and homes unlit

Andrew Cool took night sky data from hill above Carrickalinga (next page). The milky way is clearly visible even with the Adelaide sky dome. The other nighttime images all taken by Sheryn Pitman and Mark Earl, residents and CRA representatives.

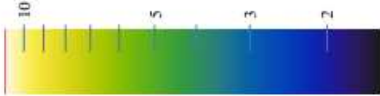
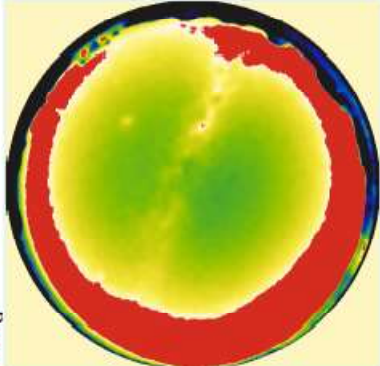
Location: CARRICKALINGA Carrickalinga
Coordinates: 138.399355 : -35.425523
Date & Time: 2023:04:21 : 09:57 Camera: EOS6D + Sigma8mm

20

FCE

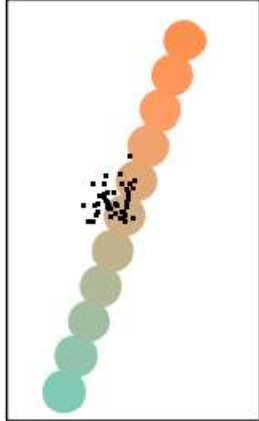
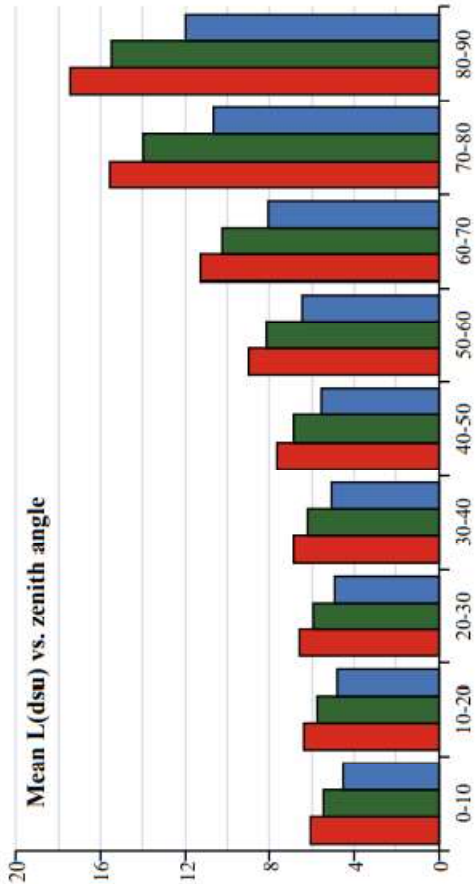


dsu_G

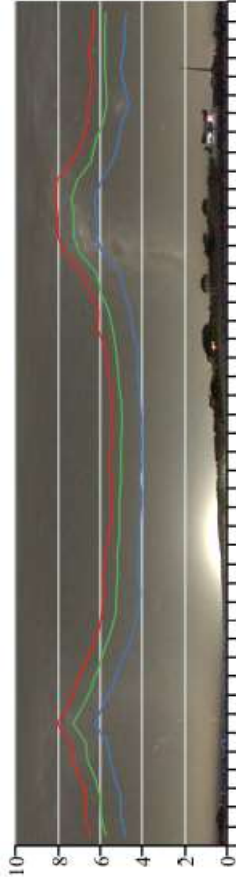
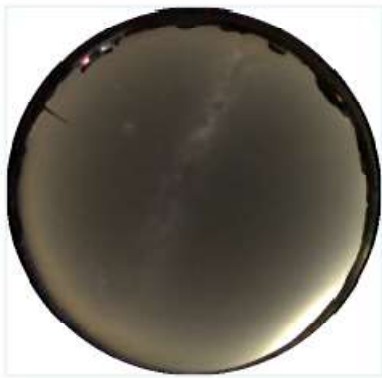


Zenith radiance: 5.47 dsu_G Minimum sky radiance: 4.87 dsu_G
0.44 mcd/m² 0.39 mcd/m²
21.02 mag/as² 21.15 mag/as²

Mean L(dsu) vs. zenith angle



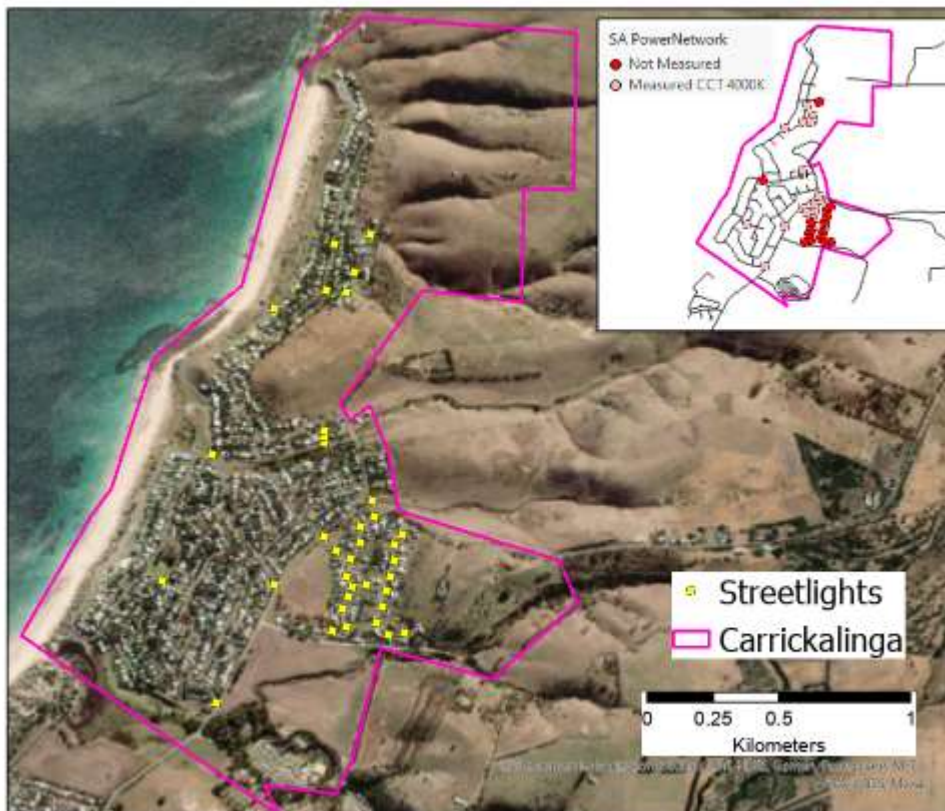
Observer(s): Andrew Cool
Raw File: Carrickalinga.CR2
ISO: 1600.0 Shutter: 60.2 Aperture: 4.0



Carrickalinga Near Light Pollution (With NASA Earth at Night)



Town Boundary Map (Satellite View) with Streetlights



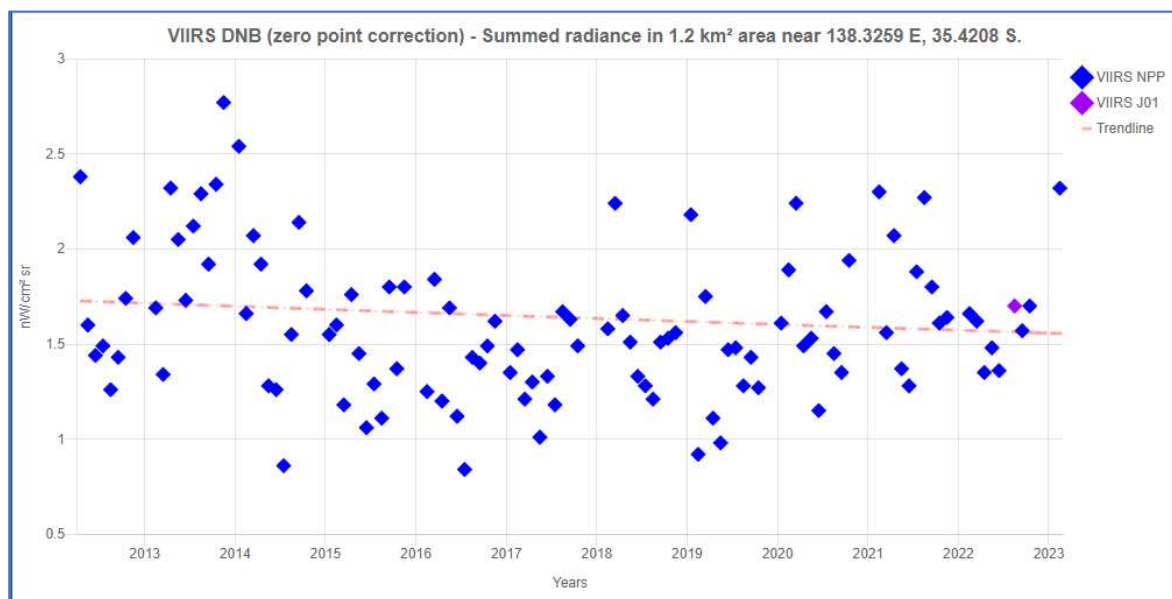
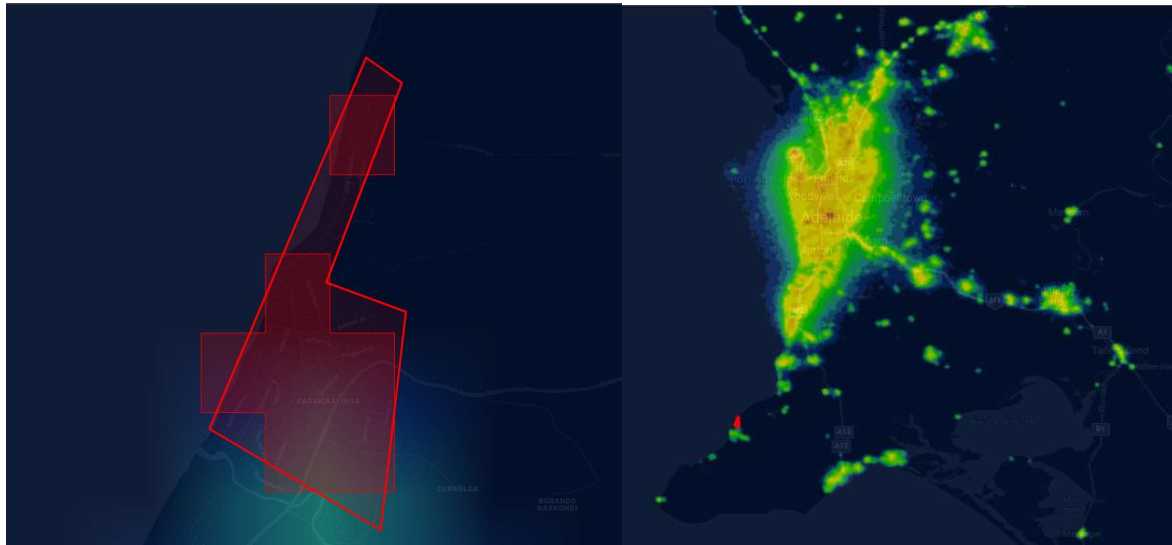
Carrickalinga night sky: Overview of General Condition

SQM data have been collected for the last two years in Carrickalinga. The average over the time span for New Moon only collections with no clouds: SQM average = 21.04 and with clouds SQM average = 20.86. For the 22 nights of collection when the moon was not visible the average SQM reading was 20.66. Over Carrickalinga the night sky is excellent as seen in the photographs taken by Fraser from the Backyard Universe during 2022/2023 tours. Please see Section 5: Monitoring and Data Collection along with Appendix C for more detailed data discussion.



(photos by Fraser of The Backyard Universe)

The satellite data from Radiance Light Trends website ([Radiance light trends \(lightpollutionmap.info\)](https://lightpollutionmap.info)) shows that Carrickalinga area is dark despite the expanding Adelaide Metropolitan area. The sky in the 1.5 km² red box (township of Carrickalinga) is trending to end value of 1.5 nW/cm²sr where in the centre of Adelaide the values rise to over 80 nW/cm²sr. This data suggests that Carrickalinga does indeed have a dark sky.



The three figures represent screenshots from the Radiance Light Trends website which uses VIIRS DNB (zero point corrected) data for time series of selected locations. The top left image is the area that is aligned with the current boundaries of the town, the right image is zoomed out to show encroachment from the major urban area of Adelaide and the lower graph is the radiance from the Carrickalinga township data from 2012 to 2023.

Section 3 Outdoor Lighting Ordinance

History of Lighting in Carrickalinga

Kim Baker, Past-President of the Carrickalinga Ratepayers Association, wrote the following letter to the District of Yankalilla Council explaining the desire of the community to apply to be the first IDA certified Dark Sky Community (Appendix A).



Dear Mayor, Interim Chief Executive & Elected Members, Yankalilla District Council
PO Box 9 Charles Street Yankalilla SA 5203

Further to the *Dark Sky Community* presentation at the Yankalilla District Council Elected Members Forum at Second Valley Hall Tuesday 7th June 2022 by Sharolyn Anderson (Ph.D Data Scientist, Crawford School of Public Policy, The Australian National University).

As mentioned in this presentation, the Carrickalinga Ratepayers Association (CRA) will be responsible for lodging the said application to IDA (International Dark Sky Communities).

The Carrickalinga community is fully supportive of this initiative and as such, CRA members have contributed funding towards its fulfilment.

We understand a Notice of Motion will be presented at the Council meeting Tuesday 21st June.

As background to the IDA application: The Carrickalinga community is an ideal candidate for becoming an International Dark Sky Community. It is unique in that it is one of very few accessible, urbanised places that does not contain traditional street lighting. Australia has one International Dark Sky reserve (River Murray) and an International Dark Sky Park (Warrumbungle National Park); however, as of now, there are no International Dark Sky Communities in Australia. **Carrickalinga is therefore the ideal candidate to be the first International Dark Sky Community in Australia.**

South Australia Power Networks has confirmed in writing, retrofitting aero-screens to the current existing LEDs in Carrickalinga would cost around \$3,000. This includes 2 x \$100 V cat HID lights which would need to be changed to LED as well as the existing 34 LED 17s in Carrickalinga. The CRA will be responsible for meeting the around \$3,000 cost of these light shields.

The CRA and Sharolyn Anderson will work with Council on the development of a Lighting Ordinance Policy.

Council will provide:

1. A letter providing the Carrickalinga Ratepayers Association with in-principle support for *Carrickalinga - Australia's First Dark Sky Community* application,
2. A *Lighting Ordinance Policy* prepared by Council Administration for the Carrickalinga township in accordance with the "International Dark Sky Community Program Guidelines June 2018" and that this be brought back to Council for endorsement before proceeding to community consultation.

The CRA looks forward to working with Yankalilla District Council and the IDA in being an eligible candidate to becoming Australia's first International Dark Sky Community.

Yours faithfully

Kim Baker

President - Carrickalinga Ratepayers Association
M +61 411 862 978 PO Box 2162, Normanville SA 5204
CC Sharolyn Anderson

2022 Dark Sky Lighting Ordinance

The Dark Sky Lighting Policy or Ordinance was started in 2021 where two presentations were made to the Council of District of Yankalilla. After clarifying and presenting again in 2022 the motion was brought to the full council. They voted to have a public consultation for 6 weeks from 29 September 2022 and closed 13 November 2022. During that time the district address the comments made by Ashley Wilson of IDA. Once the consultant period completed and there was overwhelming support for the Dark Sky Lighting Policy. The policy which addressed comments from International Dark Skies (Appendix B & H) was passed in 20 December 2022 (page 5 for letter with unanimously passed highlighted towards the end).

The first page is presented below showing the date of approval.

Dark Sky Lighting Policy - Carrickalinga



**District Council
of Yankalilla**

Dark Sky Lighting Policy - Carrickalinga

Strategic Reference	Provide leadership, good governance, and efficient, effective and responsive Council services
File Reference / Record No	18/067/229 /NGO223073
Responsibility	Operations
Version Number	2.0
Last Revised Date	December 2022
Minute Book Reference	C22268
Next Review Date	December 2024
Applicable Legislation	Local Government Act 1999; Planning, Development and Infrastructure Act, 2016 Australian Standards; Electricity Act 1996
Related Policies	Nil
Related Procedures / Documents	SA Power Networks Technical Standard - TS101 International Dark Sky Community Program Guidelines 2018 Manual of Legal Responsibilities and technical Requirements for Traffic Control Devices

1. Objective

- 1.1. The District Council of Yankalilla recognises the uniqueness and opportunities available to communities within the district to seek recognition from the International Dark-Sky Association as an International Dark Sky Community. This is the case given the limited existing lighting infrastructure within the semi-rural environment and coastal townships, together with the shelter provided from suburban light spill by the hills throughout the district.
- 1.2. The International Dark-Sky Association encourages outdoor lighting practices that will minimise light pollution, glare, light trespass, and sky glow in order to preserve the natural dark of the night sky, prevent lighting nuisances on properties and reduce

Page 1 of 6

Note: electronic version in the Synergy Records Management System is the controlled version. Printed copies are considered uncontrolled. Before using a printed copy as reference, verify that it is the current version.



In accordance with Neighborhood Zoning sporting and event arenas are prohibited in the residentially zoned Carrickalinga. The only development permitted is residential as seen in PlanSA map. In addition, Carrickalinga has no illuminated signs and should any be installed the lighting policy ensures that they will meet the Dark Sky requirements per the existing lighting policy The Council approved lighting policy refers to night sky-friendly lighting that meets the “International Dark Sky Community Program Guidelines June 2018.” In section 5.2 of the Council policy, similar language is used to reflect the five principles for responsible outdoor lighting requiring shielding, only where necessary, CCT of 3000K or preferably 2200K, and appropriate intensity for use. Currently per the approved 2019 plan guide on page 28 *“The area is well serviced by sporting clubs which are located in Yankalilla and Normanville”*, thus it can be inferred that no additional sporting clubs are needed or planned for in Carrickalinga.

Section 4 Community Outreach

Community Events

Carrickalinga hosted two events in 2022 and during 2023 the Carrickalinga Ratepayers Association continued to work with Yankalilla Council, Festival Fleurieu and the wider community to engage in spreading the benefits of dark skies. Dark Sky presentations were made in January 2023 and January 2024 to the wider Carrickalinga community.

During the Festival Fleurieu in 2021 (annual festival), there was an Introduction to Astrophotography offered by The Backyard Universe and supported by Dark Sky committee. In 2021, the event was pre-registered as full, however, it rained the night of the event and it had to be cancelled. We are looking forward to the future and working with Backyard Universe and others to ensure that there are Night Sky friendly events offered during the Festival Fleurieu.



INTRODUCTION TO ASTROPHOTOGRAPHY (FREE)

Bungala Park, Normanville 

BOOKINGS ESSENTIAL

Friday 9 April 7:00pm



Introduction to
photographing the night
sky with your digital SLR
camera. Limited numbers.
Weather permitting –
there must be a clear sky.

During the Festival Fleurieu 2021, the Dark Sky Committee and the University of South Australia Planetarium had an information booth. We conducted 36 interviews and spoke with additional visitors about the preservation of the Dark Skies at Carrickalinga and light pollution issues (Appendix D).



In preparation for this application, Dark Sky Committee presented to the District Council of Yankalilla and Carrickalinga Ratepayers Association. Presentations by Sharolyn Anderson in 2021 and updates by Sheryn Pitman in 2023 and 2024. The Annual General Meeting (AGM) is held annually and in January 2024 Sheryn Pitman provided an update presentation on the status of the Carrickalinga Dark Sky application. Fraser from The Backyard Universe conducts regular astronomy nights on the hills above Carrickalinga township.

In addition, the Carrickalinga Dark Sky Committee members have been approached by several communities to share information on the application process and importance of being a dark sky community. The community at Aireys Inlet on the Surf Coast in the state of Victoria invited Dr. Pitman to present during their community stargazing event. In addition, the committee is supporting Clayton Bay on a similar path toward Dark Sky certification.



Supporting community outreach, CRA has a monthly agenda item “Dark Sky – update”. This agenda item is helping keep the community informed of the application status, the current events the Dark Sky Committee is hosting, and any other information the committee is working on, for example, the launch of the Carrickalinga Star Party with special guest astronomers at large.

Amy Gebhardt, current President of CRA, is a professional filmmaker and is currently involved in making a documentary including the Carrickalinga night sky. When complete this will be available to the local and wider community

Carrickalinga Dark Sky Community

Carrickalinga Star Party

Join us in this star-studded party to
celebrate Carrickalinga becoming the First
Dark Sky Community in Australia

Where: Forktree Project, Forktree Road,
Carrickalinga

Date: Saturday 6th April 2024

Time: 6:00pm for 6:30pm Official Launch

Followed by stargazing space explorations
and science presentations hosted by
astronomers at large!

Drinks and nibbles included

Proudly brought to you by:

Carrickalinga.com.au
RATEPAYERS ASSOCIATION



The free tourist and local monthly news magazine, The Yankalilla and Regional News, hosts a column written by a supporter of this application, Fraser and his local business “The Backyard Universe”. The articles contribute to promotion of the IDA certification for Carrickalinga.

The Night Shift!

How and when to see an aurora from the Fleurieu Peninsula.

Yes it can be done! The Raminigdi & Kaurua people both have traditions about aurora seen from here. But first, some background...

It's been known for centuries that the Sun has dark spots on its surface, each lasting for a few days to a few weeks, and whose numbers vary over a 10 to 12 year period (solar cycle). These sunspots are only dark by contrast, their temperatures of 3500-4500 degrees making them less bright than the 5500 degrees of the Sun's usual surface. Occasionally a sunspot will get big enough to be resolved through a solar eclipse filter; and there are descriptions from antiquity of large sunspots being seen when the Sun was dimmed by clouds or haze. The current solar cycle (and numbers) of sunspots is expected to peak in mid 2025.

During the 20th century astronomers discovered that sunspots were regions of intense magnetic activity, and that sunspots were also associated with solar flares (intense outbursts of X-rays & UV light) and coronal mass ejections (ejections of magnetised plasma). The frequency and strength of these events also follow the solar cycle. During the peak, expect 2 or 3 big coronal mass ejections per day. During the minimum, 2 or 3 small ejections per week. However, not every sunspot produces these events and most of them aren't directed at the Earth. A coronal mass ejection that is directed at the Earth takes 1 to 5 days to arrive here, and when it arrives it dramatically affects the Earth's magnetic field.

The Earth's magnetic field extends tens of thousands of km into space, and like all magnetic fields it interacts with electrically charged particles. In fact the Earth's magnetic field has trapped two permanent donut-shaped belts of charged particles – the Van Allen radiation belts – and it always is.

Aurora over the Great Australian Bight
from the International Space Station

collecting more from interplanetary space. Collisions of these particles with spacecraft are a known radiation hazard in Earth orbit. There is a constant leakage of particles from the Van Allen belts, along the Earth's magnetic field towards the north & south magnetic poles. These particles never reach the poles because the Earth's atmosphere blocks the way. If we're these charged particles constantly colliding with the upper atmosphere that creates the aurora. Charged particles colliding with oxygen atoms above 150km altitude create the red light of the highest part of an aurora. At lower altitudes collisions with nitrogen molecules + oxygen atoms become more dominant, creating green light via reactions that take tens of seconds to complete. The lower edge of the green aurora is about 85km altitude where oxygen atoms are replaced by oxygen molecules, which don't produce visible light from particle collisions. Below 85km particle collisions with nitrogen molecules produce blue and red auroral light. The yellows, greens, magentas, and other colours are produced by combining the red greens & blue. Auroras also produce emissions in infrared and ultraviolet light.

On a global view the aurora occurs within two oval rings, approximately centred on each magnetic pole but displaced towards the night side of the Earth. And when things are magnetically quiet the southern hemisphere's auroral oval is visible only from Antarctica. The situation changes when a coronal mass ejection arrives, overloading the Earth's magnetic field with a million tons or more of electrically charged particles (plus their collective magnetic fields). What follows next is still not fully understood but the effects include:

- * Magnetic disturbances to the Earth's magnetic field. Geophysicists and archaeologists can't do sensitive magnetic surveys, and even your compass can misbehave.
- * Electric electrical currents get induced in any long metal artifacts such as pipelines, electrical grids, railways and telecommunications wiring. These currents flow can destroy unprotected equipment.
- * Radiation and charged particles flood along the Earth's magnetic field into the magnetic poles & areas above the auroral oval and intensify their overall oval from the polar regions into the lower latitudes, where we might see them.

Aurora near Mid (Victoria), 5 Nov 2023

with The Backyard Universe

These events are collectively referred to as Space Weather and commonly summarised using two severity scales. The older Kp Index is a measure of magnetic disturbances due to solar activity, and it's measured using a global network of magnetic observations on a scale from 0 (quiet) to 9 (extremely disturbed). The US National Oceanic & Atmospheric Administration (NOAA) uses a geomagnetic storm scale from G1 (minor storm) to G5 (major storm), using measurements from magnetic observatories and from various Sun-watching spacecraft. Either or both scales are open to various space weather and aurora websites & apps.

* Kp 5+ storm level G2+ => Very faint red aurora on the southern horizon, Kp 6+ storm level G3+ => Aurora covers the southern sky and extends into the northern sky, colours and structures are spectacular. Possibly bear that the imaginary aurora at the Hubbert memorial? Your name is in the Brisbane and Alice Springs are wondering "what's that red glow in the night sky? Is it a bushfire?" Your other name is SA Power Networks are worrying about grid stability. And your satellite internet & TV have probably stopped working. Expect only a few of these per solar cycle.

The prerequisites for our local aurora are:

- * A high state of solar activity, including a big coronal mass ejection directed towards Earth more likely.
- * A prediction of Kp of 6 or more, or a storm level of G2 or more, during our night time. Beware of reading US-based aurora websites that only use US local times.

What we might see locally when we get repeat of the G2-G3 geomagnetic storms

Kp = 6 (or more) NOAA storm level G2+ (colour was not visible to the eye)

Bright planets in January-February:

Mars is visible in the eastern morning sky during January, rising to its greatest height above the dawn by Jan 13 before dipping towards the horizon for the rest of the month. It's hidden behind the Sun's glare by early February. On the morning of Jan 28 Mercury and Mars are only 14 degrees apart below the 'hugger' – see the footer chart. Binoculars will help distinguish the brighter Mercury from the fainter Mars. Mars is Jan 14. On the mornings of Feb 21 & 24 Venus and Mars are less than 1 degree apart.

Mars appears from behind the Sun in mid-January, very low in the eastern morning twilight. By late February it's rising about dawn. Another is the 'brightest' star visible in the northern evening sky, as soon as it gets dark, during January & February. Its cloud bands and its four biggest moons are visible in a small telescope. So bright though you. And we see an ever changing arrangement of these moons because their orbits are almost edge-on to our view, their orbital periods range from 42.5 hours to 87.9 days, and they also pass in front of and behind Jupiter.

Saturn is dropping into the western evening twilight by late January and a hidden behind the Sun's glare from mid February.

During January the Moon passes near Venus on the morning of Jan 9, near Mercury & Mars on the morning of Jan 10 (very low in the east), near Saturn on Jan 14, and near Jupiter on Jan 18 & 19. During February it passes near Venus & Mars on the morning of Feb 4, near Mercury & Mars on the morning of Feb 9, near Saturn very low in the west on Feb 11, and near Jupiter on Feb 15.

The Moon is also close to the Pleiades star cluster again on Jan 20-21. If you have a clear western horizon and binoculars you can watch the Moon passing across the cluster from about 11pm until midnight. There's a repeat performance on Feb 16-17 but it's not visible from Australia.

First Quarter Moon Jan 8 & Feb 3, New Moon Jan 11 & Feb 16, First Quarter Moon Jan 18 & Feb 17, Full Moon Jan 20 & Feb 24. Closest approaches to Earth are on Jan 13 & Feb 11.

Sept 2022 – Yankalilla Regional News – Announcing Carrickalinga IDA application

An international bid for Carrickalinga to become Australia's first Dark Sky Community

The Fleurieu Peninsula is beautiful in many ways, and one is the fact that we have little light pollution in comparison with many places in the world. Light pollution is affecting skies globally in increasing and disturbing ways, yet many have heard of it or even considered that light can be a form of pollution. However if you look at a satellite image of the Earth at night, you'll see just how it up our planet has become.

In a way it looks beautiful indeed, twinkling with so many lights. However there is a problem – a big one in fact. Dark skies are disappearing and that negatively impacts life on Earth in a myriad of ways including human health and well-being and the ecosystems that support life.

Light pollution is simply the presence of unwanted, inappropriate or excessive artificial lighting. Artificial light is light ranging in wavelength from the ultra violet to the near-infrared that is caused, directed or used by humans for any purpose.

Sleep disorders, obesity, breast cancer and depression are linked to light pollution. Negative effects on our native wildlife include disturbance of predator-prey relationships, foraging and feeding, mating and reproduction, way-finding and migration. For example, light pollution can act as an 'ecological trap' for many insects. Insects are essential light eaters in the food web and yet they are undergoing a mass extinction around the world and yet they are essential light eaters in the food web and yet they are undergoing a mass extinction around the world.

These impacts are in addition to our own enjoyment of the night sky and visibility for astronomers. There is a plethora of scientific evidence in health and biological sciences – that light pollution is a growing problem.

However there is light at the end of the tunnel, so to speak! The International Dark Sky (IDS) Association is made up of scientists in varying fields (physics, astronomy, health, biology, ecology), health professionals, educators, policy makers, engineers and business people from around the world.

The world. It is the recognised authority on light pollution and is leading organisation advocating light pollution worldwide. The vision of the Association – the night sky, filled with stars, is celebrated and protected around the world as a shared heritage benefiting all living things.

The purpose is to protect the night from light pollution. In the District Council of Yankalilla are incredibly fortunate to be in a world of many dark skies. Most unadorned communities of the past. The danger is in us taking what we have for granted. In fact light pollution is on a rise in our world, and it provides global recognition of the special nature of the place and community we have here. There are no down-sides – there is only benefit and advantage for everyone. It is a simple and exciting.

We are delighted that Council has agreed to work with the community on this proposal, and is showing leadership in this endeavour. Dark skies are incredibly valuable for many reasons and with your support we can contribute to the global movement to protect them while continuing to enjoy our own night skies into the future. Please indicate your support by emailing DarkSkyCarrickalinga@gmail.com or through the QR code attached.

Dr Sheryn Pinnar, Carrickalinga, in collaboration with the Sherrin Anderson and the Carrickalinga Rangespeakers Association.

Alpaca Shearer

Available for coming season. Small mobs - 1 to 20 head. Call Greg 0429 842 388

Koala Rescue

Kate 0410 678 954

Native Animal Rescue

Available 24/7 for all native animal rescues Call Sharon Brathwaite 0437 856 175. Maria Gull Ridge, 10462 Fines Point

Fauna Rescue

8289 0896 including kangaroos Koala Hollister 1300 KOALAS Fauna Rescue of SA Inc.

Broken Wing Raptor Rescue

Birds of prey (Raptors) Phone Maggie 0417 819 698 pumple@bigpond.com

are not aggressive and won't chase you. If a person is bitten, call 000. Wrap a pressure bandage tightly over the area of the bite, then use a second bandage and splint to immobilise the limb. Keep the person calm and still until you can get medical help.

For more information on how to maintain your property to reduce the likelihood of snakes, visit the DEW website: <http://www.environment.sa.gov.au/>

Stay safe as spring sunshine signals start of snake season

22/08/22
Kee your eyes peeled outdoors. As warmer spring days sees South Australia's snakes either out from their winter sleep, signalling the start of snake breeding season. The Department for Environment and Water (DEW) has issued its annual reminder for the community, in particular, campers, hikers and motorists, to be on the lookout for snakes both in metro and regional areas.

DEW's Principal Ecologist, Dr Karl Hillyard explained the increase in snakes brings snakes out of hibernation (a hibernation-like state). You can avoid snakes on your property by keeping your yard clear of long grass and removing any rubbish that may offer snakes a good spot to hide.

Hillyard said, "Eastern brown snakes in particular are found everywhere, but each region has its local specialty. The Adelaide Hills has the red-bellied black snake, the River Murray kangaroo island and south coast have the tiger snake, while annual reminder for the community, in particular, campers, hikers and motorists, to be on the lookout for snakes both in metro and regional areas."

"Just because you've never seen a snake on your property doesn't mean they aren't there, so you should always be careful about putting your hands or feet into spots where you can't see."

"You can avoid snakes on your property by keeping your yard clear of long grass and removing any rubbish that may offer snakes a good spot to hide."

The Night Shift!

Venus and Saturn are both visible in the eastern sky as soon as it gets dark, and Mercury is in the western evening plains this month. Jupiter

the Southern

Mercury Sep 1

Mercury Sep 3

Ben McKenzie PLUMBING AND GAS

MOB 0419 827 045
OFFICE - BEC 8558 8184
0406 656 248

- Hot Water Services and Septics
- Hot and Cold Water
- Rainwater Tanks
- General Maintenance
- Storm Water
- Blocked Drains

Yankalilla Regional News - September 2022 - Page 32

FREE FELLING & LOPPING

• Free Quotes • 25+ years experience • Competitive pricing • Fully Insured • Call Geoff - 0411 117 113 (Saw-miller to the Governor)

Southern Ocean Construction

Asbestos Removal n 8429 954 125 Curtis Wilson n 9826 Adelaide n 8001 590 Laundry
Quotes - Advice
www.southernoceanconstruction.com

Yankalilla Regional News - September 2022 - Page 33

THE NIGHT SHIFT, at The Backyard Universe.

It's summer so we've lost the bright central regions of the Milky Way from our evening skies for a while. But we're gaining the summertime Milky Way rising in the east. And on the darker nights we have both of the Magellanic Clouds high in the southern sky, looking like detached blobs of the Milky Way.

We've also got the Geminids meteor shower this month; best seen after midnight from about Dec 9 to Dec 17. The maximum of 100+ meteors per hour is predicted for Dec 14. There's also a special "meteorite" returning to Earth this month -- the sample return capsule from the Hayabusa 2 asteroid mission. If all goes well this will parachute into the desert near Woomera on the morning of Dec 6.

The main astro event for December is the conjunction of the planets Jupiter and Saturn. They've been slowly getting closer to each other all year, and in recent weeks they've also been getting lower in the western evening sky. Jupiter is the brightest "star" in that part of the sky at the moment, with Saturn not quite so bright, above and to the right. By 9pm during December the evening sky still has a lot of twilight in it but both planets should be visible by then.

At the beginning of December they're only 2 degrees (four times the diameter of a full moon) apart. By December 17 they're only 0.5 degree apart (the diameter of a full moon); and there's a crescent moon about 3 degrees above them. Get out your binoculars and have a look. Or take a photo. Then continue looking on the next few nights as they converge [picture 1].

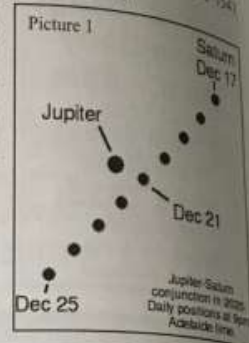
Their conjunction occurs on December 21, with a separation of just 0.1 degree (one-fifth the diameter of a full moon). You might have difficulty separating them by eyeball alone and will have to use binoculars. And if you have a telescope -- even a small one -- take a look at low magnification, and see both planets and some of their satellites all in the same field of view [picture 2]. Saturn is actually about 850 million km behind Jupiter on this night so don't worry about a collision.

These Jupiter-Saturn conjunctions occur every 19 to 20 years or so, and this one is their closest in the last 400 years. The next ones in November 2040 and April 2060 get them no closer together than 1.2 degrees. But if you can wait until March 2080, that Jupiter-Saturn conjunction is practically as close as this one. If you can't wait that long there's the close conjunctions of Jupiter & Mercury on 4 Jun

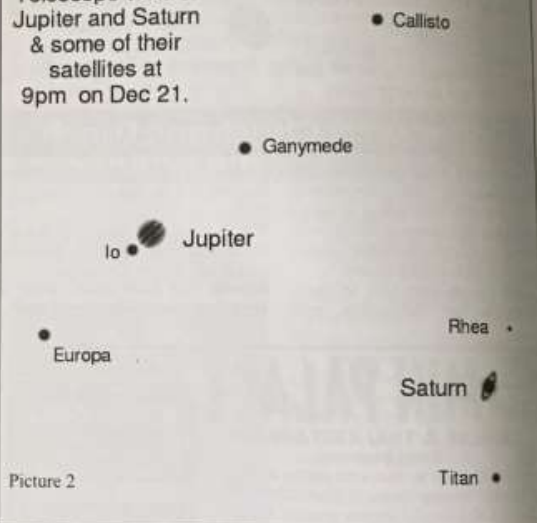
2024, or Saturn & Mars on 20 July 2036, both 0.1 degree apart. Or if you just want any two bright planets, try Mercury & Mars setting together in the twilight on 19 Aug 2021.

And does Jupiter ever eclipse Saturn, as seen from Earth? Yes but not very often. The last time it happened was over 10 thousand years ago, and the next time it's due

to happen is on 17-18 June 2541 (Adelaide time).



Telescope view of Jupiter and Saturn & some of their satellites at 9pm on Dec 21.



Picture 2

NORMANVILLE
Edward Avenue

YANKALILLA
Wallman Street

SELF STORAGE DO YOU NEED STORAGE?

Household goods, shop stock, trade tools, business records? Long or short term available.

Range of sizes include:

2.2m x 4.5m, 3.0m x 4.0m, 3.0m x 6.0m, 3.3m x 9.0m

Ray White Normanville
(Managing Agents)
67 Main South Road, Normanville
Phone 8558 3050

PRICE ROBERTS & CO Chartered Accountants Tax Agents and Business Advisors

Specialising in:

- Small Business Management & Taxation
- Bookkeeping & BAS
- Business Benchmarking & Analysis
- Taxation Consulting
- Superannuation & Self Managed Funds

Yankalilla, 83 Main Road
Victor Harbor, 34 Victoria Street
Telephone: 8552 2822

Phone appointments
only during Covid19
restrictions

SeatoCity CONVEYANCING

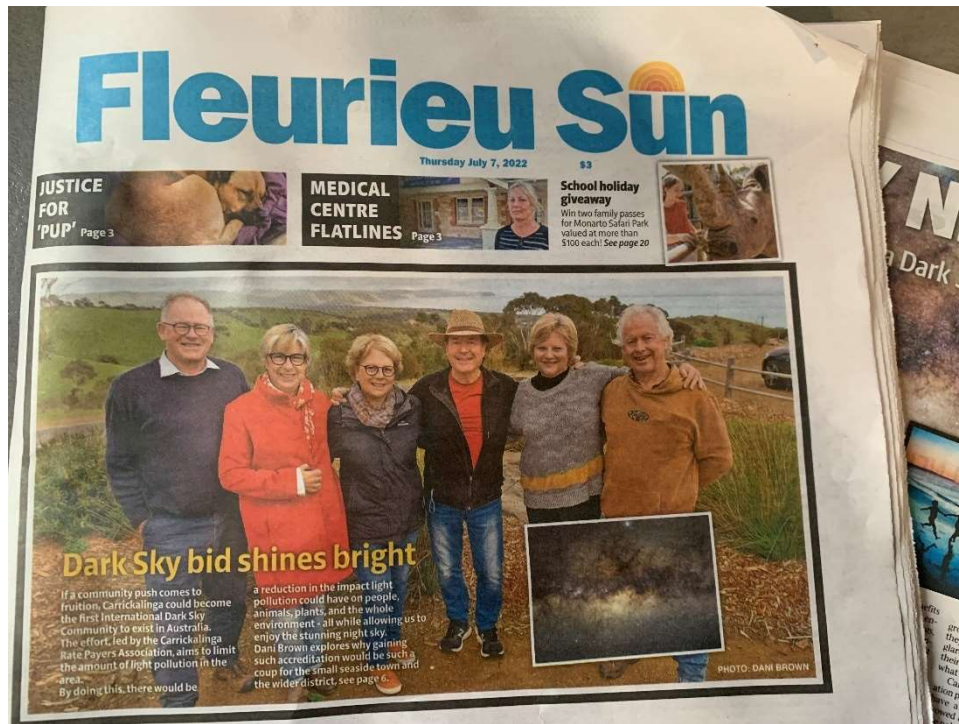
Amy Hunt (nee Fretwell)
REGISTERED CONVEYANCER
Buying or Selling property? Or Perhaps you need advice about a property transfer, land division, business sale. If so contact Amy your local Conveyancer.
Phone: 0407 793 672
Office situated at 1 Mary Avenue Normanville (by appointment)
Email: info@seatocty.com.au
Fax: 8558 2580
Ask about our DISCOUNT for First Home Buyers and Pensioners!

Locksmiths On The Fleurieu

Home and rental
Sensible prices
Quality service
Standard rates on weekends
Phone Paul
0419 030 998
8556 8131
www.lotf.com.au

Area media has covered the announcement that Carrickalinga is seeking Dark Sky Community designation including the local and state newspapers. Please see screen shots below.





INDAILY
SALIFE
CityMag

NEWS BUSINESS OPINION EAT | DRINK | EXPLORE iSpy PREMIUM PROPERTY review SALIFE CityMag EVENTS

Monday, Oct 10, 2022

Carrickalinga looking to become Australia's first Dark Sky Community

REGIONAL NEWS

The Carrickalinga Ratepayers Association is pushing ahead with an application for the town to become Australia's first Dark Sky Community after gaining support from the Yankalilla District Council.

Katarina Bozic

Support our work
Click here to donate

[Twitter](#)
[Facebook](#)
[LinkedIn](#)
[Email](#)

https://indaily.co/382437

Print article

The centre of the Milky Way as seen from Wirrina, near Carrickalinga. Picture: The Backyard Universe

The association and council are working together in order to adopt a Dark Sky Lighting Policy which is required in order to progress the application to become a globally recognised accreditation.

Professor Chris Daniels, a ratepayer and resident of Carrickalinga, is one of the community's strong advocates for Carrickalinga to become a Dark Sky Community.

"We have this issue now where big cities produce a huge amount of light," he said.

"They produce a dull glow which actually inhibits our view of the stars, and this is a really big issue because our kids are growing up without seeing stars."

Dark Skies concept gains traction

By Matt Welch Carrickalinga

The Times
Thursday 22nd December 2022
492 words
Page 8 | Section: NEWS
440cm on the page



Dark Skies concept gains traction

Yankalilla Council

Matt Welch
Carrickalinga

THE District of Yankalilla Council have discussed a possible endorsement of a new Dark Skies initiative for one Fleurieu township.

At the Tuesday, December 20, 2022 meeting, Yankalilla Council was proposed with a motion to support and commit to the concept of Carrickalinga becoming a Dark Sky Community.

Council were also asked to present the results of community engagement on the concept and endorse the amended Dark Sky Lighting.

Being a holiday destination Carrickalinga hosts a rural atmosphere and village character.

With Dark Skies encouraging people to visit the area, the community has a desire to preserve its character and protect the natural environment.

With only 38 streetlights in the township, the spill of light pollution would be at a minimum, but community commitment would be needed to enforce this to ensure the Dark Sky experience is fulfilled for the long term.

Cr Davina Quicke moved the motion and hoped councillors accepted the Dark Skies motion.

"The media publicity this concept will get will not just



District of Yankalilla Council have discussed a possible endorsement of a new Dark Skies initiative for Carrickalinga.
Picture, Dave Hartley Photography.

be local, but international," Cr Quicke said.

Cr Glen Rowlands said he attended the inaugural meeting about Dark Skies and said he originally had concerns on what it was going to cost the council.

"Not so much in the facts of promotion or support, but council landing with the responsibilities," Cr Rowlands said.

"While it's all very good at the moment with the ratepayers association, we may see that change and come

back to us (council) in the future having to manage and do the work.

"If this is another cost for our ratepayers, it may not seem much, but over time it's another responsibility.

"I do like the idea, and we are unique being so close to Adelaide and having a Dark Sky. I won't say I'll support this reluctantly, but to make my point, as time goes by, will it land in our lap?"

Cr David Olsson said that right from the start he's been supportive of the concept,

but also shares Cr Rowlands concerns.

"This is an ongoing commitment and I do hope the Carrickalinga ratepayers association stays true and actually follows through with their pre-existing commitments," Cr Olsson said.

Cr Simon Rothwell said he raised a potential problem with the concept with the Carrickalinga community.

"There's no point in having a light shade if you have a spot light shining down the road," Cr Rothwell said.

"I asked how they were going to keep the community committed to keeping lighting down."

Yankalilla Council's Chief Executive Officer, Nathan Cunningham said it would be a community commitment and obligation in regards to keeping personal lighting to a minimum.

With less than 40 accredited Dark Sky communities in the world at this stage, Carrickalinga's motion for the dark skies consultation was carried unanimously.

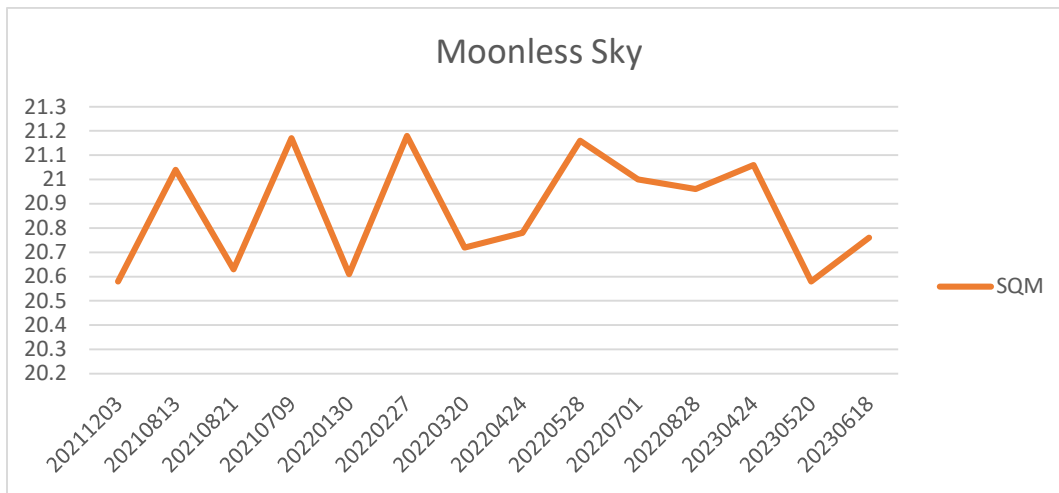
Content within this media item are licensed by Copyright Agency. You must not copy this work without permission. You may only copy or communicate this email and the work(s) within with an appropriate license. Copyright Stream Pty Ltd, 2022.

Stream

Section 5 Monitoring and Data Collection

Procedure (Current)

We began collecting SQM measurements in March 2021. The Unihedron Sky Quality Meter SQM-L was used to measure the magnitudes per square arc second of sky brightness. Following the DarkSky methods, the unit was pointed towards the zenith and five measurements were taken with the first one being disregarded and the last four averaged for final recorded value. Here is a summary of the March 2021 to June 2023 readings (for individual readings and data logging sheet please see Appendix C).



The average on a moonless night sky is 20.66 taken from the star location on the map. The monthly measuring is completed by a volunteer member of the CRA and appointed annually by the Dark Sky Committee. The dates from 2021-2023 were completed by Sheryn Pitman and Mark Earl (residents). Fraser from The Backyard Universe supports Carrickalinga becoming a dark sky community. Therefore, he collected the data on Wednesday March 3, 2021 at the locations send on the map See Appendix C for raw data collection sheets. These are the same locations that are proposed for the monitoring sites.



SQM measurement were taken during the night sky tours by Fraser of The Backyard Universe at the Forktree Project. The average measurement at this location was 21.45 (Appendix C).

Procedure (Proposed Monitoring)

A single location will continue via the Carrickalinga Ratepayers Association (CRA) annual volunteer. Fraser will contribute data

on an ad-hoc bases and when ask by CRA. in the future with support from the CRA a Citizen Science Dark Sky Monitoring event every year similar to Torrey, Utah a certified IDA Community has been planned.

We will emulate the flier (mockup below) and plan to hold annual events. With time, we hope to include the students from the Yankalilla Area School and integrate the First Nations.

Annual Citizen Science Dark Sky Monitoring Party

Who?
People of all ages are invited to participate! Bring a red torch or headlamp.

What?
We'll carpool or walk to six locations in Carrickalinga to collect night sky data.

When?
First New Moon Friday in December from 8pm to 10pm.

Where?
Center Park (intersection of Lyddon Rd, Tuna Cres and Lewis Rd) and then visit stars on the map!





Why?
The better we know our sky quality the better we can protect it!

More information
Carrickalinga.com or email CarrickalingaDarkSky@gmail.com
Or contact any member of the Carrickalinga Ratepayers Association.

Section 6 Community Support

There were three phases to engage the community and evaluate level of support. The events were 1) the 'farmer's market' during the Festival Fleurieu 2021 where we collected and analyzed 36 survey collected during the event, 2) CRA Survey, and 3) Yankalilla District Council community consultation which began Thursday 29 September and closed Sunday 13 November 2022.

1) The Farmer's Market Survey

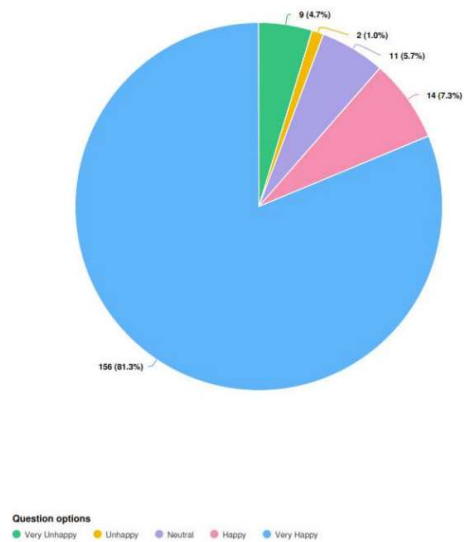
Early community outreach on the viability of having Carrickalinga designated as an IDA certified Dark Sky Community included two paper (face to face) surveys of public knowledge and attitudes. The first survey was administered at a continuing education course in Aboriginal Astronomy at the University of South Australia. This survey was completed by 26 respondents (example in Appendix D) on March 25th, 2021. The second was conducted at the Farmer's Market in Carrickalinga on April 10th, 2021. The Farmer's Market survey was completed by 29 respondents (example in Appendix E). The Farmer's Market survey results showed overwhelming support for designation of Carrickalinga as an IDA certified Dark Sky Community with respondents overwhelmingly recognizing that dark skies are important for ecosystem function, human health, and the economic health of the community. These responses did not vary significantly based on age, sex, income, or level of education. The respondents to the survey conducted at the University of South Australia's continuing education course were somewhat more supportive of designation of Carrickalinga as an IDA certified Dark Sky Community despite the fact that the majority of the respondents had no particular relationship with the area and most had never even been there. This is perhaps not surprising because these respondents were a biased sample because they were enrolled in a course titled: Night Skies and the Aboriginal Cosmos.

2) CRA Survey with Dark Skies question on support

The CRA sent out a survey prior to the annual meeting which asked a number of questions that concerned the residents, one being the application to become an international dark sky community. The response rate was low however there complete support with agree and strongly agree to the initiative. The 2023 CRA Annual Meeting there was a sign up list for all in support of Carrickalinga becoming the first IDA certified Dark Sky Community (Appendix A).

3) District Council of Yankalilla 90 day Consultation

The consultation results supported the Council's decision to pass the lighting ordinance and validated that the community is over 85% supportive of the initiative. The results of survey are presented in District Council of Yankalilla Consultation Report (Appendix F).



Again, over 85% of respondents are happy or very happy with the proposal to have Carrickalinga become an IDA certified Dark Sky Community.

The consultation worked with the help of our Dark Sky Committee to educate and inform the community of the initiative. The committee worked with the Council on the video script, the FAQ, the overall website for the consultation and the flyer which was mailed out to all residents of Carrickalinga. The website also had a special video by Chris Daniels, a resident and Professor of Urban Ecology (<https://www.yoursayyankalilla.com.au/dark-sky-carrickalinga/widgets/386374/videos/26133>) explaining the Dark Sky Lighting Policy and the benefits to all.

In addition to the website and video there was a Dark Sky Information flyer sent to all Carrickalinga residents, an FAQ available on line, and a postcard with information set out at the Yankalilla Visitor Center and Museum. (Flyer below and please see all consultation documents in Appendix G.)

3) CRA Annual General Meeting

The Carrickalinga Ratepayers Association are progressing an application for Carrickalinga to become Australia's first Dark Sky Community.

In order to progress the application, it requires Council to adopt a Dark Sky Policy.

The Carrickalinga Ratepayers Association and Council are working together, and we invite you to share your views on the draft Dark Sky Lighting Policy.

What is a Dark Sky?

A Dark Sky is a natural night sky unaffected by light pollution.

What is the Dark Skies movement?

It is an international commitment to protect the night skies for present and future generations. For over two decades, the International Dark-Sky Association has managed the award-winning International Dark Sky Places Program.

The movement encourages communities all over the world to upgrade to more efficient and appropriate lighting, to reduce unnecessary lighting, and to value the night skies for their benefits and beauty.

Australia has amazing night skies, such as those of Carrickalinga, and yet these too are being continually degraded by surrounding light pollution.

Becoming a Dark Sky Community will help protect the community and environment from local light pollution and provide inspiration for surrounding areas to protect our spectacular night sky.

What is light pollution?

Light pollution, or artificial light at night, is the presence of unwanted, inappropriate or excessive artificial lighting. Light pollution is one of the most significant changes that humans have made to the natural environment and can have serious consequences for humans, wildlife, ecosystems and our climate. It is a rapidly growing problem around the world.

What is smart lighting?

Lighting is 'smart' when appropriate for the task, and refers to where, when and the amount of light produced. This is better termed 'smart lighting design' where the need, the timing and the minimum requirements for light are assessed.

Smart lighting means that we:



Use **targeted lighting** - light only when and where we need



Use **shielded lights** and direct them downward, avoiding light trespass



Use **energy efficient bulbs** that are no brighter than necessary



Use **warm white or amber-coloured bulbs**



Use controls such as **motion sensors** and **dimmers**



Is smart lighting safe?

It is an urban myth that more light is safer. In truth, the research finds that well-designed lighting is safer.

Carefully targeted and uniform lighting are critical elements of night-time safety. Bright and glary lights are shown to detract from safety.

'Dark sky' does not mean 'dark ground'. Smart lighting means you can have a dark sky without losing light on the ground.

Why become a Dark Sky Community?

There are human health, ecological health and economic benefits in protecting the natural night sky.

The human health benefits are many and range from better sleep to physical and mental well-being. Plants and animals, and indeed whole ecosystems, have evolved with the natural day/night cycles and so keeping this as natural as possible is of great benefit for wildlife, and essential for the survival of many species.

Economic benefits are also very clear, with energy savings translating directly into monetary savings. This also helps with mitigation of climate change by reducing energy production emissions into the atmosphere. Investment in the future of dark skies is valuable for many reasons.

Why Carrickalinga?

The "Made by Nature" Fleurieu Coast community of Carrickalinga has only 38 streetlights. The upgrade of these lights can be achieved for little cost and effort and the Carrickalinga Ratepayers Association who are driving this proposal and will be responsible for all activities required to receive a Dark Skies Communities Accreditation, including the cost of light shields, and working with Council on the development of a Dark Sky Lighting Policy.

Carrickalinga could then become the first Dark Sky Community in Australia. With less than forty such 'communities' in the world at this stage, this would be a great accomplishment indeed.

This initiative of the Carrickalinga Rate Payers Association aims to not only reduce light pollution, improve human and environmental health, and save both money and energy while reducing greenhouse gas emissions, residents and visitors alike can enjoy the night skies into the future.

Stargazing brings joy and wonder to all of us in different ways and the starry skies of the Fleurieu Peninsula are precious.



Bortle Scale 1- Excellent 9 - City Sky

The Draft Policy

The draft Dark Sky Lighting Policy is based on the requirements of the International Dark Sky Community Program Guidelines.

This policy shall apply to the Designated Area of Carrickalinga Township who through the Carrickalinga

Ratepayers Association are actively seeking accreditation from the International Dark-Sky Association as a Dark Sky Community.

Council, under this Dark Sky Lighting policy aims to;

- Ensure that Council, other Government bodies and private landholders within an area designated understands how they can assist attaining, preserving, and promoting the Dark Sky Community concept.
- Ensure all new public lighting within an area designated meets the standards and requirements.
- Retrofit existing outdoor public lighting within an area designated to ensure it meets the standards and requirements.
- Confirm that the costs for delivery of infrastructure works are to be borne by the groups requesting the Dark Sky infrastructure; noting that in this case, the Carrickalinga Residents Association have offered to bear these costs.

The Policy aims to minimise the light pollution and promote 'Dark Sky friendly lighting' by considering the following principles;

Outdoor public lighting should only be installed when deemed necessary and should only be activated when needed,

- All outdoor lighting should be directed downwards so that light spill is avoided,
- Fittings should include light shields so that light it is directed downwards,
- The intensity of outdoor lighting should be appropriate for its intended use,
- Coordinated colour temperature (CCT) of lighting shall be less than 3000 K.

The Draft Dark Sky Lighting Policy does not seek to limit development or remove existing lighting, however outlines a minimum standard to provide adequate lighting under current Australian standards while utilising Dark Sky Friendly principles.

Council is seeking community feedback on the Draft Dark Sky Lighting Policy before the Council consider formally adopting the policy.

You can find the full policy, more information and complete the online survey via www.yoursayyankalilla.com.au, send an email to consultation@yankalilla.sa.gov.au or write to The District Council of Yankalilla PO Box 9, Yankalilla.

Consultation Opens Thursday 29 September and closes Friday 11 November 2022.

1 Charles Street, Yankalilla SA 5203 08 8558 0200
Open Monday to Friday 9:00am - 5:00pm
council@yankalilla.sa.gov.au yankalilla.sa.gov.au



Carrickalinga
RATEPAYERS ASSOCIATION

Section 7: Lighting Management Plan

The Township of Carrickalinga is completely residential with only 38 street lights. The new codes and standards for public lighting are outlined in the Dark Sky Lighting Ordinance and provides clear guidelines for night sky friendly lighting following the Dark Sky principles, suggestions, and requirements. Currently 36 street lights are not in compliance and will be made compliant over the next five years in collaboration with the Yankalilla Council and South Australia Power Networks (SAPN) (Appendix H for map and specification). Discussions are ongoing to move forward working over the next five years to achieve compliance. CRA has raised the funds to pay for the Greenhill lighting design and implementation report and begin the retrofit. CRA, Council and SAPN are currently conducting an analysis to determine which of the following options is the best way to achieve compliance for the existing and future lights: 1) adding dimmers, 2) replacement of 4000K LEDs with 3000K or preferred 2200K LEDs, or 3) moving entire district to smart lighting. The residential lighting compliance component will be take place over the next five years as indicated in Section 8. Please see Appendix B for the policy document encompassing the future of lighting in Carrickalinga.

In addition, section 5.8 of the policy states that the Council is committed to addressing the compliance within the existing infrastructure. Sections pasted below for clarity:

5.8 Council recognizes that existing luminaires and public lighting infrastructure may not meet the requirements for lighting under the 'International Dark Sky Community Program Guidelines (June 2018)'. In these cases, Council will work with communities seeking Dark Sky accreditation to prepare a lighting replacement plan to ensure that public lighting conforms with Dark Sky Standards (as well as current Australian standards) within a timeframe of no more than 5 years from official recognition of the area as a Dark Sky Community. These works are to be funded by the relevant community or community interest group who puts forward the request/ application for accreditation.

5.9. The District Council of Yankalilla commits to ensuring Dark Sky appropriate lighting will be designed and located accordingly when renewing or upgrading Council owned lighting within an area which has sought (or has received) accreditation.

Lighting projects

Actions and plans around street lighting upgrade

Progress to bring the current streetlights in the township of Carrickalinga into compliance with both Dark Sky standards, the Carrickalinga Ratepayers Association (CRA) and the District Council of Yankalilla (Council) worked together to develop a consultant design brief and request for quote (attached) for the upgrade of 36 streetlights. This was provided to three lighting designers accredited and approved by both the Council and SA Power Networks. (SA Power Networks has the responsibility for installation.)

The project proposal and quote includes objectives outlined, including production of a street light design, on existing poles, that ensures compliance with both Australian Standards and Dark Sky compliance standards. It will include ensuring the lighting meets the latest AS1158 standards and DarkSky requirements. An estimated timeline for the upgrade is as followed yet subject to council availability: March/April – commission lighting design (CRA to fund), followed by June/July 2024 – install upgraded lighting fixtures (CRA & Council to raise funds) (Appendix I includes the consultant design brief and return brief from GREENHIL ENGINEERS.)

District Council
of Yankalilla



22/09/2023

Dear Sharolyn,

RE: Dark Sky Lighting Policy - Carrickalinga

The District Council of Yankalilla adopted the Dark Sky Lighting Policy - Carrickalinga at their meeting on the 20th December 2022.

Since adoption of this policy there has been no public construction or private development applications proposing changes to lighting within the policy area.

Council will continue to actively consider the adopted Dark Sky Lighting Policy when assessing any future public and private development applications proposing changes to lighting covered under the Dark Sky Lighting Policy - Carrickalinga

Yours sincerely,

A handwritten signature in blue ink, appearing to read "Patrick Langlands", is written over a faint, larger version of the same signature.

Patrick Langlands
Infrastructure Manager
District Council of Yankalilla

1 Charles Street
(PO Box 9)
Yankalilla SA 5203
yankalilla.sa.gov.au

Phone (08) 8558 0200
Fax (08) 8559 2022
Email council@yankalilla.sa.gov.au
ABN 17 163 010 187

YANKALILLA

Section 8: Carrickalinga Five Year Activity Plan

The Carrickalinga Dark Sky Community Five Year Plan reflects the community's enthusiasm and commitment to this initiative, and incorporates a full range of activities including: public lighting design and upgrade (CRA, Council, Greenhill Engineers, SA Power Networks); community awareness surveys (CRA, Council); signage installation (Council); community and local school education (CRA, Council, school); SQM and monitoring (CRA); data collection and analysis (CRA); fundraising (CRA, Council); public education outreach activities and events (CRA, Council, local astronomers); involvement of First Nations in public outreach (CRA); domestic lighting upgrade campaign (CRA, Council, local suppliers); website development and maintenance (CRA, Council); annual reporting or IDS, Council and community (CRA); and annual celebration and education events (CRA, Council).

Summary Table of Timelines

	Action	Ed/Outreach	Data/reporting
	Kickoff Greenhill retrofit project	Update signage	Routine SQM data collection
2024	Raise funds	Official Launch - Carrickalinga Star Party	Community data collection event
	Residential Survey	Design CRA DarkSky website	Submit annual report*
	CRA and Council will review the lighting policy	Festival Fleuria events	
	Continue retrofit streetlights	Begin public campaign	Routine SQM data collection
2025	Establish partnerships with lighting supplier	Annual Star Party	Community data collection event
	One-to-one support for residents	Festival Fleuria events	Submit annual report*
	Continue retrofit streetlights	Continue public campaign	Routine SQM data collection
2026	Expand partnerships with lighting supplier	Annual Star Party	Community data collection event
	One-to-one support for residents	Festival Fleuria events	Submit annual report*
		Update CRA DarkSky website as needed	
	Complete retrofit streetlights	Continue public campaign	Routine SQM data collection
2027	Continue partnerships with lighting supplier	Annual Star Party	Community data collection event
	One-to-one support for residents	Festival Fleuria events	Submit annual report*
	One-to-one support for residents	Continue public campaign	Routine SQM data collection
2028	Complete privately owned retrofits	Annual Star Party	Community data collection event
	CRA and Council will review the lighting policy	Festival Fleuria events	Submit annual report*
		Update CRA DarkSky website as needed	

For each year there are the actions (•), education/outreach (◦), and data/reporting (🌀)

2024

- Accept the return brief and authorize Greenhill Engineering LTD to design the retrofit of the streetlights in Carrickalinga
- Raise funds through Council and grant processes for the retrofit installation of lighting fixtures as approved
- Undertake a social science residential survey of private lighting to identify barriers to and opportunities for the installation of night sky friendly lighting
 - update the welcome to Carrickalinga (Sign shown on cover) to include DarkSky International Logo
 - light pollution and astronomy public outreach (such as: night sky tours, celebrating Dark Sky

Week, Globe at Night campaign, work with First Nations, etc.)

- begin a public education campaign on improving current conditions to Dark Sky specification
- encourage light pollution and astronomy education in nearby Normanville schools
- design and launch Carrickalinga DarkSky website (Carrickalinga Dark Sky Committee owns Carrickalinga.com domain and CarrickalingaDarkSky@gmail.com)

☯ local residents (Sheryn Pitman and Mark Earl) continue regular sky quality measurements

☯ Launch annual data collection and community event with The Forktree Project and invited guests, including the District Council of Yankalilla Mayor, Parliament member for Mawson District, and many more.

☯ Carrickalinga Dark Sky Committee (all members of the local CRA) submit annual DarkSky report with photo log of retrofit project

2025

• Continue to retrofit public street lighting (as per GREENHILL ENGINEERING) in association with SAPN and Council as necessary – *provide a photo journal of the retrofits each annual report

• Utilize the residential lighting survey results to establish night sky-friendly lighting campaign

- Establish partnerships with lighting suppliers in local area, eg Bunnings, Buckford Illumination Group
- Write grant to South Australia government for funds to support residents who need financial help and seek other financial support for residents if needed
- Give workshops and one-to-one support for home inventories and retrofit of lighting
- Light pollution and astronomy public outreach (such as: night sky tours, celebrating Dark Sky Week, Globe at Night campaign, etc.)
- Provide materials for light pollution and astronomical education in nearby Normanville schools
- Evaluate and update Carrickalinga DarkSky website to include results and responses to survey

☯ CRA members continue regular sky quality measurements

☯ CRA members continue annual data collection and community event

☯ CRA members submit annual DarkSky report with support from Carrickalinga Dark Sky Committee

2026

• Continue to retrofit public street lighting (as per GREENHILL ENGINEERING) in association with SAPN and Council as necessary (expected to have completed retrofit)

• Commence and support changing privately owned outdoor lighting of private residences

- Continue ongoing partnerships with lighting suppliers in local area, eg Bunnings, Buckford Illumination Group
- Continue work with grant funds from South Australia government to support residents who need financial help and seek other financial support for residents if needed
- Give workshops and one-to-one support for home inventories and retrofit of lighting
- Light pollution and astronomy public outreach (such as: night sky tours, celebrating Dark Sky

Week, Globe at Night campaign, etc.)

- Provide materials for light pollution and astronomical education in nearby Normanville schools
- Evaluate and update Carrickalinga DarkSky website to include results and responses to survey

☯ CRA members continue regular sky quality measurements

☯ CRA members continue annual data collection and community event

☯ CRA members submit annual DarkSky report

2027

• If necessary continue to retrofit public street lighting (as per GREENHILL ENGINEERING) in association with SAPN and Council

• Commence and support changing privately owned outdoor lighting of private residences

- Continue ongoing partnerships with lighting suppliers in local area, eg Bunnings, Buckford Illumination Group
- Write addition grants for funding and continue work with grant funds from South Australia government to support residents who need financial help and seek other financial support for residents if needed
- Give workshops and one-to-one support for home inventories and retrofit of lighting
- Light pollution and astronomy public outreach (such as: night sky tours, celebrating Dark Sky Week, Globe at Night campaign, etc.)
- Provide materials for light pollution and astronomical education in local schools
- Evaluate and update Carrickalinga DarkSky website to include results and responses to survey

☯ CRA members continue regular sky quality measurements

☯ CRA members continue annual data collection and community event

☯ CRA members submit annual DarkSky report

2028

• complete the retrofit 36 street lighting in association with SAPN and Council

• complete changing privately owned outdoor lighting of private residences

- light pollution and astronomy public outreach (such as: night sky tours, celebrating Dark Sky Week, Globe at Night campaign, etc.)
- continue light pollution and astronomy educational support in local schools
- update Carrickalinga DarkSky website

☯ CRA and Council will review the lighting policy and see if possible add statement to address any potential outdoor recreational lighting

☯ CRA members continue regular sky quality measurements

☯ CRA members continue annual data collection and community event

🌀 CRA members submit annual DarkSky report

Future plans of the Carrickalinga International Dark Sky Community:

- encourage expansion of the good lighting practices applied in the township of Carrickalinga to the surrounding jurisdictions
- ensure the Carrickalinga Area beyond the townships is also compliant
- confirm Carrickalinga as an astro-tourism destination and branding as dark sky friendly
- collaborate with the Australasian Dark Sky Alliance and First Nations (Traditional Owners)

Appendix A: Letters of Support and Signed Support Documents

Appendix B: Dark Sky Lighting Policy – Carrickalinga

Appendix C: SQM Raw Data Collection

Appendix D: Survey results for UniSA’s Aboriginal Astronomy course

Appendix E: Survey results from the Farmer’s Market in Normanville

Appendix F: District Council of Yankalilla Report

Appendix G: Consultations Resources for Residents

Appendix H: Carrickalinga Streetlights

Appendix I: Greenhill Project No: P23.3457 – Carrickalinga Streetlight Upgrade

Appendix A

Letters of Support and Signed Support Documents

Carrickalinga South Environment Group

7 February 2023

Dear International Dark Sky Places Committee,

On behalf of the members of the Carrickalinga South Environment Group, I am delighted to wholeheartedly support the nomination for Carrickalinga to become a Dark Sky Community, the first in Australia.

Carrickalinga is very special place within the District of Yankalilla on the Fleurieu Peninsula of South Australia, with a community that has long-resisted a number of the trappings of urbanisation such as street lighting. For many years members of the local community have worked together to protect and conserve the natural environment of the area, and this includes the dark skies that so many appreciate and enjoy.

I am excited to have our community rewarded for many years of contributions to looking after our natural world, and also to officially joining the global movement to address light pollution.

Kind regards

A handwritten signature in black ink, appearing to read 'Sheryn Pitman', with a stylized, flowing script.

Dr Sheryn Pitman

(+61) 0499903390 / sheryn.pitman@sa.gov.au

Chair, Carrickalinga South Environment Group

Chair, Yankalilla Bay Dune Care Group (1994-2010)

Chair, Yankalilla District Dunes and Coastal Management Advisory Committee (1996-2010)

Thursday 20th July, 2023

Dear International Dark Sky Places Committee,

I am writing to express my unwavering support for the establishment of a Dark Sky Community in Carrickalinga and to emphasize the paramount importance of preserving our natural nightscapes. As an astronomer and concerned citizen advocating for environmental conservation, I firmly believe that fostering a Dark Sky Community is a crucial step towards safeguarding our environment and the well-being of our community.

In recent years, rapid urbanization and technological advancements have inadvertently led to an alarming increase in light pollution. Artificial lighting not only disrupts the delicate balance of our ecosystem but also impacts human health and wildlife in numerous ways. As artificial lights obscure the night skies, we lose our connection to the stars, planets, and the wonderment of the universe above.

The importance of a Dark Sky Community cannot be overstated. By implementing responsible lighting practices and regulations, we can drastically reduce light pollution and its adverse effects. Some key reasons why a Dark Sky Community is vital are as follows:

Environmental Preservation: Artificial lighting disrupts ecosystems, affecting wildlife migration, nesting patterns, and other natural behaviours. By promoting responsible outdoor lighting, we can protect our local flora and fauna.

Energy Conservation: Unnecessary and excessive outdoor lighting wastes energy and resources. By adopting dark sky-friendly lighting fixtures and practices, we can significantly reduce energy consumption, leading to cost savings and a more sustainable future.

Human Health and Well-being: Artificial light at night disrupts our natural sleep patterns, leading to various health issues, including insomnia and fatigue. Restoring a dark night sky can have positive impacts on human health and improve overall well-being.

Tourism and Economy: Dark Sky Communities attract tourists and astronomy enthusiasts seeking pristine views of the night sky. This influx of visitors can stimulate local economies through increased tourism and related activities.

Cultural and Educational Value: A dark night sky has been an integral part of human history and cultural heritage. Restoring it provides an opportunity to reconnect with our past and inspire future generations to explore and appreciate science and astronomy.

I urge the Dark Sky Community Association to work closely with local authorities, businesses, and residents to develop and implement a comprehensive plan that encourages responsible outdoor lighting and actively seeks the Dark Sky Community designation. By doing so, we can ensure the preservation of our night skies for generations to come.

In conclusion, I pledge my support and willingness to participate in any initiatives, events, or campaigns aimed at promoting dark sky awareness and conservation efforts. Together, we can make a significant difference in protecting our environment and promoting sustainable practices.

Thank you for your dedication to this critical cause. I look forward to witnessing the positive impact of a Dark Sky Community on our region and the world beyond.

Sincerely,

Mary Adam
Astronomer/Astronomy Educator
Administration Assistant
School of STEM
University Of South Australia
T +61 8 8302 3138
M +61 0411 519 468
Mary.Adam@unisa.edu.au



UniSA STEM
City East Campus
Frome Road
Adelaide
South Australia 5000
t: +61 8 8302 2227
f: +61 8 8302 2252

Mawson Lakes Campus
Mawson Lakes Boulevard
Mawson Lakes
South Australia 5095
t: +61 8 8302 3000
f: +61 8 8302 5082

GPO Box 2471
Adelaide
South Australia 5001
Australia
www.unisa.edu.au/nbe
CRICOS Provider Number 00121B



University of
South Australia

13th February, 2023.

Associate Professor Delene Weber
UniSA STEM
University of South Australia
Mawson Lakes Campus
Mawson Lakes, SA 5095
Australia

Dear International Dark Sky Places Committee,

I am delighted to support the nomination of Carrickalinga in South Australia, to become Australia's first Dark Sky community. If you have had the privilege to visit Carrickalinga on South Australia's Fleurieu Peninsula, you would probably have experienced a sense of calm, relaxation, and connection with nature as you listen to the waves gently wash upon the shore. The community, in the District of Yankalilla, has benefited from many forward-thinking community members who have fought hard to keep this little piece of paradise, more natural and less developed than almost any other community within close proximity to a capital city. Awarding the community as a Dark Sky Community, will go one step further in promoting the protection of nature, sustainability, and the need to address light pollution. Darkness is crucial for so many reasons, particularly for the diversity of wildlife in the area.

People also need dark places to retreat to for their own well-being. The restorative value of darkness has been well documented. We can always develop an area more, but it is challenging to "un-develop" an area. I sincerely hope the committee sees the virtues of this nomination and the symbolic value it can bring to a country that prides itself on an "outdoorsy" lifestyle, but is failing to recognise the importance of dark skies. I am looking forward to future monitoring of this community and using it as a case-study in my classes to examine flow-on effects of this classification. Hopefully, it will be a catalyst for greater attention to light pollution. I sincerely thank all those who have been involved in nominating this community and reviewing the documentation and I look forward to a future of bright stars in the dark sky at Carrickalinga. Please don't hesitate to get in touch if you require further information.

Sincerely,

Professor Delene Weber

UniSA STEM | Bldg P | Mawson Lakes Campus | Office F2-24
Mawson Lakes SA | 5095
Delene.weber@unisa.edu.au
+61 8 8302-5279
CRICOS Provider Number 00121B

**UniSA STEM
City East Campus**
Frome Road
Adelaide
South Australia 5000

t: +61 8 8302 2227
f: +61 8 8302 2252

Mawson Lakes Campus
Mawson Lakes Boulevard
Mawson Lakes
South Australia 5095

t: +61 8 8302 3000
f: +61 8 8302 5082

GPO Box 2471
Adelaide
South Australia 5001
Australia

www.unisa.edu.au/nbe
CRICOS Provider Number 00121B



The Backyard Universe Pty Ltd
PO Box 235 Yankalilla
SA 5203
Australia

3 March 2023

To: The International Dark-Sky Association www.darksky.org

We support the Carrickalinga Dark Sky Community proposal

We've been running our commercial tourism business *The Backyard Universe* and its unique multicultural night sky tour within the District Council of Yankalilla since 2016. Before then we operated a conventional astro tour in this district, as a paying hobby, since the early 1990s. We also live in this district, so we've been long-term witnesses to the changes in its night skies and outdoor lighting.

You can read about our night sky tour here:

<https://www.thebackyarduniverse.com.au/starForktree.htm>

The Forktree tour venue is inside the official boundary of Carrickalinga but outside of the township area, so it's named for the hill it's located on. We describe our tour as multicultural because it includes night sky interpretations from many southern hemisphere indigenous cultures, including both of our local Aboriginal groups. The tour also introduces some traditional Chinese and Indian constellations. These have been very popular with tourists & emigres from those two countries; most of whom live/lived in large cities and haven't seen a natural night sky before.

According to our own measurements most of the District Council of Yankalilla, outside of the main townships, still has night skies as dark as the River Murray Dark Sky Reserve. The south coast of the district has skies as dark as the Outback but this coast is also a magnet for fog & low clouds at night! Within the smaller townships like Carrickalinga it's still possible to find public places there with moonless SQMs of 21.4 or better. *Starry night skies* have been identified by many respondents when surveyed about the desirable aspects of living in this district.

Our Forktree tour venue provides an excellent demonstration of light pollution. Its northern horizon is afflicted by the ~200,000 outdoor lights of metropolitan Adelaide. But in other directions and overhead the night sky is still mostly unspoiled; including over Carrickalinga township. During tours we routinely see Zodiacal Light, low clouds as black starless silhouettes, both Magellanic Clouds, the occasional aurora australis, and of course in intricate detail overhead the Milky Way. Or as it was known at Forktree for thousands of years before us, *Wodli Parri*.

We've been recording SQMs and moon phase (if it's visible) during our tours for many years. The results are described in our blog post "why we don't do tours during full moons": <https://www.thebackyarduniverse.com.au/blog.htm>

The graph of visible stars -vs- moon phase was constructed for our latitude after correcting Yale Bright Star Catalogue magnitudes for atmospheric extinction. Also using Unihedron's

online calculators to convert SQMs to NELMs, and then counting how many of our visible stars are brighter. We've also done many SQMs outside of our district to provide the other lines on the graph. Thus we've measured that our local skies are (almost) as good as the remotest Outback yet still within driving distance of a large Australian city. Which is the reason we chose our business name.

So we were very pleased when the residents of Carrickalinga, on their own initiative and expense, decided to become a Dark Sky Community. In fact when we had to find a new tour venue we eventually chose the rural hills above Carrickalinga, partly because the township wants to be a Dark Sky Community. We've been supporting this proposal for a while with community astro events in the township and positive comments about it in our monthly local newspaper articles. But we're letting the residents lead it because (a) it's their town not ours, and (b) we would be accused of having purely commercial motivations if we led it.

Of course we'd eventually like to see a Dark Sky initiative encompassing the entire District Council area and all of its townships (including ours), but this Carrickalinga proposal is an excellent first step to that goal.

Fraser Farrell
owner/operator

E tbu@thebackyarduniverse.com.au
M (+61) 0488 705 224
W www.thebackyarduniverse.com.au



<http://eclipses.au> -- Australia's total solar eclipses in 2023 2028 2030 2037 & 2038

Dear Mayor, Interim Chief Executive & Elected Members, Yankalilla District Council

PO Box 9 Charles Street Yankalilla SA 5203

Further to the *Dark Sky Community* presentation at the Yankalilla District Council Elected Members Forum at Second Valley Hall Tuesday 7th June 2022 by Sharolyn Anderson (Ph.D Data Scientist, Crawford School of Public Policy, The Australian National University).

As mentioned in this presentation, the Carrickalinga Ratepayers Association (CRA) will be responsible for lodging the said application to IDA (International Dark Sky Communities).

The Carrickalinga community is fully supportive of this initiative and as such, CRA members have contributed funding towards its fulfilment.

We understand a Notice of Motion will be presented at the Council meeting Tuesday 21st June.

As background to the IDA application: The Carrickalinga community is an ideal candidate for becoming an International Dark Sky Community. It is unique in that it is one of very few accessible, urbanised places that does not contain traditional street lighting. Australia has one International Dark Sky reserve (River Murray) and an International Dark Sky Park (Warrumbungle National Park); however, as of now, there are no International Dark Sky Communities in Australia. **Carrickalinga is therefore the ideal candidate to be the first International Dark Sky Community in Australia.**

South Australia Power Networks has confirmed in writing, retrofitting aero-screens to the current existing LEDs in Carrickalinga would cost around \$3,000. This includes 2 x S100 V cat HID lights which would need to be changed to LED as well as the existing 34 LED 17s in Carrickalinga. The CRA will be responsible for meeting the around \$3,000 cost of these light shields.

The CRA and Sharolyn Anderson will work with Council on the development of a Lighting Ordinance Policy.

Council will provide:

1. A letter providing the Carrickalinga Ratepayers Association with in-principle support for *Carrickalinga - Australia's First Dark Sky Community* application,
2. A *Lighting Ordinance Policy* prepared by Council Administration for the Carrickalinga township in accordance with the "International Dark Sky Community Program Guidelines June 2018" and that this be brought back to Council for endorsement before proceeding to community consultation.

The CRA looks forward to working with Yankalilla District Council and the IDA in being an eligible candidate to becoming Australia's first International Dark Sky Community.

Yours faithfully

Kim Baker

President - Carrickalinga Ratepayers Association
M +61 411 862 978 PO Box 2162, Normanville SA 5204
CC Sharolyn Anderson



22 June 2022

Doc Ref: NOCE221601
File Ref: 9/025/854

The International Dark Sky Places Program Manager
C/- The Carrickalinga Ratepayers Association
PO Box 2162
NORMANVILLE SA 5204

Dear International Dark Sky Places Program Manager

Letter of Support: Carrickalinga – Australia's First Dark Sky Community

Following ongoing discussions and engagement with the Carrickalinga Ratepayers Association in relation to the benefits of International Dark Skies Communities and the opportunity to support the application for Carrickalinga to be Australia's first Dark Sky Community, the District Council of Yankalilla, at its meeting on Tuesday, 22 June 2022 resolved:

1. *That Council writes a letter providing in principle support for the Carrickalinga - Australia's First Dark Sky Community application.*
2. *That Council notes that the Carrickalinga Rate Payers Association will be responsible for lodging the application.*
3. *That Council notes that the Carrickalinga Rate Payers Association will be responsible for all activities required to receive a Dark Skies Communities Accreditation, including the cost of installation of light shields, and working with Council on the development of a Lighting Policy.*
4. *That Administration prepare a Lighting Policy for the Carrickalinga township in accordance with the "International Dark Sky Community Program Guidelines June 2018" and that this be brought back to Council for endorsement before proceeding to community consultation.*

Council looks forward to seeing this initiative progress in our community and acknowledge the work of the Carrickalinga Ratepayers Association to make it happen.

Yours sincerely

A handwritten signature in blue ink, appearing to read "SR", is written over a light blue horizontal line.

Simon Rothwell
Mayor

**Dark Sky Community Support
Carrickalinga Ratepayers Association**

Number	Name	Email (if you want to be added to the Dark Skies Mailing list)
1	Dawna Quinke	dawnquinke@icloud.com
2	John Quinke JP	johnsod@gmail.com
3	Erin Quinke	erinquinke@internode.on.net
4	Mike Dardenne	mike.dardenne@hotmail.com
5	Alison Hughes	alison.h@kookmail.com
6	Joel Lawler	lawlerjoel@bigpond.com.au
7	Joel Lawler	lawlerjoel@bigpond.com.au
8	Colin Ross	colin@rockbrook.com.au
9	Karen Lemerai	rockbrook@gmail.com
10	Leith Summers	leithsummers@gmail.com
11	Janice Baker	janicebaker@gmail.com

Number	Name	Email (if you want to be added to the Dark Skies Mailing list)
12	Luke Wrenner	luke.wrenner@bigpond.com
13	KAY LEWIS	ek.lewis@hotmail.com
14	JOHN LEWIS	"
15	Cathy Gerna	cathygera@hotmail.com
16	Brian Gerna	bjgera@optusnet.com.au
17	Rodney Dean Sharp	rodsharp1@bigpond.com
18	Mark Earl	markmarkad.com.au
19	Rob TIDD	rob.tidd@gmail.com
20	Rae Reynolds	c.r.reynolds@live.com
21	Chris Reynolds	"
22	Chri Lemerai	cplemerai@gmail.com

Number	Name	Email (if you want to be added to the Dark Skies Mailing list)
23	Glaine Sutton	crel@sutton.com.au
24	Tim Cox	timcox@bigpond.net.au
25	Ann Gregory (KUPA)	ann.gregory@gmail.com
26	Peter Stewart	peter@novelland.com.au
27	Jonathan Harty	jonharty@internode.on.net
28	ROB BALL	robball@gmail.com
29	Anne Ball	anneball@gmail.com
30	David Minns	minnsd@gmail.com
31	Anthea Bosworth	anthea@internode.on.net
32	Rene Bosworth	"
33	CHRIS BROUGHAM	chris.brougham@gmail.com

Number	Name	Email (if you want to be added to the Dark Skies Mailing list)
58	Karin Hatch	mkhatch@bigpond.com
59	Michael Hatch	"
60	Daniel Catherwood	danielcatherwood@gmail.com
61	Mike Clark	ericf.las@gmail.com
62	J. CLARK	julianeflase@gmail.com
63	ANNA STEEN	anna.s.steen@gmail.com
64	Bill Varnum	billvarnum@bigpond.net.au
65	Dance Labe	janiebaker@gmail.com
66	Chris Daniels	cdaniels@gmail.com
67	Shawn Pedra	shawnpedra@gmail.com
68	Kim Baker	kbakeram.com.au

Number	Name	Email (if you want to be added to the Dark Skies Mailing list)
34	Jackie Robson	jackie.robson@hotmail.com
35	MARY CAWTHAN	marycawth@gmail.com
36	Bill Cawth	billcawth@bigpond.com
37	David Cawth	"
38	Angie Gibhardt	angie@ext.com.au
39		
40		
41		
42		
43		
44		

Appendix B

Dark Sky Lighting Policy – Carrickalinga



Dark Sky Lighting Policy - Carrickalinga

Strategic Reference	Provide leadership, good governance, and efficient, effective and responsive Council services
File Reference / Record No	18/067/229 /NGO223073
Responsibility	Operations
Version Number	2.0
Last Revised Date	December 2022
Minute Book Reference	C22268
Next Review Date	December 2024
Applicable Legislation	Local Government Act 1999; Planning, Development and Infrastructure Act, 2016 Australian Standards; Electricity Act 1996
Related Policies	Nil
Related Procedures / Documents	SA Power Networks Technical Standard - TS101 International Dark Sky Community Program Guidelines 2018 Manual of Legal Responsibilities and technical Requirements for Traffic Control Devices

1. Objective

- 1.1. The District Council of Yankalilla recognises the uniqueness and opportunities available to communities within the district to seek recognition from the International Dark-Sky Association as an International Dark Sky Community. This is the case given the limited existing lighting infrastructure within the semi-rural environment and coastal townships, together with the shelter provided from suburban light spill by the hills throughout the district.
- 1.2. The International Dark-Sky Association encourages outdoor lighting practices that will minimise light pollution, glare, light trespass, and sky glow in order to preserve the natural dark of the night sky, prevent lighting nuisances on properties and reduce

artificial light effects on wildlife. While maintaining the rural atmosphere and village character of the town and district.

Council under this Dark Sky Lighting policy for Carrickalinga aims to;

- 1.2.1. Ensure that Council, other Government bodies and private landholders within an area designated or seeking accreditation as an International Dark Sky Community, understands how they can assist attaining, preserving, and promoting the International Dark Sky Community concept.
- 1.2.2. Ensure all new public lighting within an area designated or seeking accreditation as an International Dark Sky Community, meets the standards and requirements expected by the International Dark Sky Association.
- 1.2.3. Retrofit existing outdoor public lighting within an area designated or seeking accreditation as an International Dark Sky Community, meets the standards and requirements expected by the International Dark-Sky Association.
- 1.2.4. Confirm that the costs for delivery of infrastructure works are to be borne by the groups requesting the Dark Sky infrastructure.

2. Scope

- 2.1. This policy shall only apply to the Designated Area of Carrickalinga Township, while actively seeking or where accreditation has been gained from the International Dark-Sky Association as an International Dark Sky Community. (Note: this Policy can be updated to apply via a further Council Resolution to other areas pending a process which is to include Public Consultation on an updated Draft)

3. Definition

- 3.1. For the purpose of this Policy, certain words, phrases and terms used herein shall have the meanings assigned to them by this section:
- 3.2. DESIGNATED AREA OF CARRICKALINGA TOWNSHIP: The area of Carrickalinga, which, in the views of a reasonable person, has the look and feel of a predominantly residential township area; generally located in the 'Neighbourhood Zone' as referenced in the Planning & Design Code.
- 3.3. CORRELATED COLOR TEMPERATURE (CCT): A specification of the colour appearance of the light emitted by a lamp, relating its colour to the colour of light from a reference source when heated to a particular temperature, measured in degrees kelvin (K).
- 3.4. DIRECT ILLUMINATION: Illumination resulting from light emitted directly from a lamp, luminary or reflector. This does not include light reflected from other surfaces, such as the ground or building faces.
- 3.5. INTERNATIONAL DARK SKY COMMUNITY: An International Dark Sky Community (IDSC) is a town, city, municipality or other similar political entity that has shown exceptional dedication to the preservation of the night sky through the implementation

and enforcement of quality lighting policies, dark-sky education, and citizen support of the ideal of dark skies.

- 3.6. **FLOODLIGHT:** A fixture or lamp designed to "flood" an area with light. A specific form of lamp or fixture designed to direct its output in a specific direction. Such lamps are often designated by the manufacturer and are commonly used in residential outdoor lighting. These lights should not emit light above the 45 degree plane and they do not exceed 1,000 lumens
- 3.7. **FULLY SHIELDED:** An outdoor light fixture designed so that the installed fixture emits no light above the horizontal plane of the lowest part of the fixture. These light fixtures must be shielded in and of themselves. Surrounding structures, like canopies, are not to be considered when determining if the fixture is full cut off Fully Shielded fixtures must be appropriately mounted so that the shielding prevents light from escaping above the horizontal and all light is directed downward.
- 3.8. **LIGHT POLLUTION:** Any adverse effect of non-natural light sources. Often used to denote "sky glow" from cities or towns, but also includes glare, light trespass, visual clutter and other adverse effects of lighting.
- 3.9. **LIGHT SOURCE:** The part of a lighting fixture that produces light, e.g., the bulb.
- 3.10. **LIGHT TRESPASS:** Light falling where it is not wanted or needed. Spill light falling over property lines that illuminates adjacent grounds or buildings in an objectionable manner.
- 3.11. **LUMINAIRE:** a complete electric light unit.
- 3.12. **OUTDOOR LIGHT FIXTURE:** An outdoor electrically powered illuminating lamp or similar device used for lighting structures, parking lots, pathways, service canopies, recreational areas, signs or other similar outdoor lighting uses.
- 3.13. **RECREATIONAL LIGHTING:** Lighting used to illuminate sports fields, ball courts, playgrounds or similar outdoor recreational facilities.
- 3.14. **SPOTLIGHT:** A fixture or lamp designed to light a small area very brightly. See definition of Floodlight.
- 3.15. **UNSHIELDED FIXTURE:** A fixture that allows light to be emitted above the horizontal either directly from the lamp or indirectly from the fixture or reflector. Any fixture not full cut off.

4. Policy Statement

- 4.1. The District Council of Yankalilla recognises the uniqueness and opportunities available to communities within the district to seek recognition in the form of accreditation as an International Dark Sky Community. Given the opportunities for various communities to seek this recognition and the complex tenure arrangements (possibility of many hundreds of privately owned parcels of land) within these areas, it is proposed that management of lighting within areas designated or seeking accreditation as International Dark Sky Communities, is considered as two parts.

- 4.2. Public lighting infrastructure: being lighting infrastructure owned/ managed by Council, government bodies and/or other service authorities for the purpose of lighting public spaces and infrastructure.
- 4.3. Private infrastructure: focusing on community education, with private landowners being encouraged to upgrade existing external lights to be compliant with the International Dark Sky standards for International Dark Sky Communities.

5. Policy

New Public Infrastructure

- 5.1. If meeting all requirements under Australian standards and/ or other local authority standards, installation of all new Council managed outdoor public lighting shall be in accordance with the minimum requirements for lighting under International Dark Sky Community Program Guidelines June 2018.
- 5.2. Where possible, Lighting shall be 'Dark Sky Friendly' by considering the following principles;
 - Outdoor public lighting should only be installed when deemed necessary and should only be activated when needed
 - All outdoor lighting should be directed downwards so that light trespass is avoided
 - Fittings should include light shields so that light it is directed downwards and there is no upward lighting
 - The intensity of outdoor lighting should be appropriate for its intended use
 - Correlated colour temperature (CCT) of lighting shall be less than 3000 K. preferably 2200K

Public Street lighting

- 5.3. The District Council of Yankalilla specify the lowest lighting level category, as indicated in current Australian Standards, to keep the lighting level (and tariff costs) as low as possible; whilst recognising Council's obligations around crime prevention through environmental design (CPTED).
- 5.4. Installation of all new public street lighting will be to the minimum specifications in accordance with current Australian standards and utilising standard SA Power Networks luminaires which meet colour temperature requirements under International Dark Sky Community Program Guidelines (June 2018).
- 5.5. For all new street lighting installations shielding and/ or aero screen fittings shall be utilised as standard.
- 5.6. Layout for new street lighting shall be prepared by a suitably qualified lighting engineer, ensuring that lighting is minimised while still maintaining minimum standards required under Australian standards.

Private Development

- 5.7. Lighting plans must be prepared and provided for any new Development Applications that will lead to the development of new external lighting (public or private), this includes land division applications which require street lighting and commercial or residential developments where lighting is proposed (for example in car park areas or around buildings). Outdoor lighting plans shall be assessed against lighting principles in the 'International Dark Sky Community Program Guidelines (June 2018)', as well as relevant industry and Australian standards. To the extent that this Policy can require, those costs are to be borne by the developer.

Existing Infrastructure

- 5.8. Council recognises that existing luminaires and public lighting infrastructure may not meet the requirements for lighting under the 'International Dark Sky Community Program Guidelines (June 2018)'. In these cases, Council will work with communities seeking Dark Sky accreditation to prepare a lighting replacement plan to ensure that public lighting conforms with Dark Sky Standards (as well as current Australian standards) within a timeframe of no more than 5 years from official recognition of the area as a Dark Sky Community. These works are to be funded by the relevant community or community interest group who puts forward the request/ application for accreditation.
- 5.9. The District Council of Yankalilla commits to ensuring Dark Sky appropriate lighting will be designed and located accordingly when renewing or upgrading Council owned lighting within an area which has sought (or has received) accreditation.

Restricted lighting

- 5.10. To the extent to which this can be controlled through Legislation, Regulation, or through Council's own projects, the following lighting is to be restricted or prohibited within areas covered under this policy;
- Lighting which is directed towards the sky (unless required for safety reasons).
 - The use of searchlights, except when used by emergency personnel.
 - Lighting on advertisement signage is prohibited, except where it can be demonstrated that it meets the principles of 'Dark Sky Friendly Lighting'

6. Further Information

This policy will be available for inspection at the Council office listed below during ordinary business hours and provided to interested parties as per Council's Fees and Charges Register. Copies are available to be downloaded, free of charge, from Council's website: www.yankalilla.sa.gov.au/policies

District Council of Yankalilla
1 Charles Street
Yankalilla 5203

Phone: (08) 8558 0200

Fax: (08) 8558 2022

Email: council@yankalilla.sa.gov.au

Office hours: Monday to Friday, 9.00am to 5.00pm (except public holidays)

Page 5 of 6

Note: electronic version in the Synergy Records Management System is the controlled version. Printed copies are considered uncontrolled. Before using a printed copy as reference, verify that it is the current version.

YANKALILLA

7. Grievances

Any grievances in relation to this policy or its application should be forwarded in writing addressed to the Chief Executive Officer of Council.

8. Review Cycle

This document is subject to review in two (2) years from the date of authorisation.

9. Document History

Date	Version	Council Resolution No.	Description of changes
	1.0	C	Adoption of Policy
12/12/2022	1.1		Review of Policy – amendments provided by Sharolyn Anderson & Ashley Wilson of CRA

Policy "CARRIED Unanimously" on 20th December 2022 as seen on page 5 of this document.

Appendix C

SQM Raw Data Collection

①

Night Sky Measurements at Lat, Long: -35.42942, 138.3212

Date	Time	SQM	Moon	Phase	Cloudy	Comments
01/05/21	8.03 pm	20.92	No	Half	Cloudy Yes	Moon between full + half but not visible
07/05/21	10.05 pm	20.35	No	Half	Yes	
15/05/21	8.55 pm	20.47	No	Quarter	Yes	New to waxing
21/05/21	10.12 pm	19.54	Yes	Half	Yes	
29/05/21	8.40 pm	20.10	Yes	Three-quarter ^{full}	No	Newly waning
5/06/21	9.45 pm	20.57	No	Quarter	Yes	
11/06/21	9.42 pm	19.41	No	New	Yes	No Moon
26/06/21	9.34 pm	17.22	No but full ^{50% brightness}	Fullish	Yes	Fullish
9/07/21	9.47 pm	21.17	No	New	No	No Moon
17/07/21	9.52 pm	19.04	Yes	Half	No	
25/07/21	10.30 pm	17.61	Yes	Full	Yes	
6/08/21	11.10 pm	17.90	No	Waning Crescent	No	Not visible
13/08/21	11.00 pm	21.04	No	Quarter	partly No	Not visible
21/08/21	11.00 pm	15.13	Yes	Full	No	
28/08/21	9.35 pm	20.63	No	Half	No	
11/9/21	9.20 pm	19.96	No	Quarter	Yes	
18/9/21	9.25 pm	14.69	Yes	Fullish	No	Nearly full 93%
9/10/21	9.40 pm	20.66	Yes	Waxing ^{13%} Crescent	Yes	Moon shadowy
20/11/21	10.03 pm	19.18	Yes	Fullish	No	
3/12/21	10.05 pm	20.58	No	New	Partly	
12/01/22	10.00 pm	19.03	Yes	Half/Waxing	No	
24/01/22	9.42 pm	20.08	No	Half/Waning ^{Gibbous}	Yes	
30/01/22	9.40 pm	20.61	No	Full New	No	No moon
10/02/22	9.32 pm	19.59	Yes	Half	No	
27/02/22	10.12 pm	21.18	No	Waning ^{Crescent} Quarter	No	
20/03/22	8.35 pm	20.72	No	Waning ^{Gibbous} nearly full	partly	

SQM Data Collection at -35.429329, 138.3211373

Date	Year	Month	Day	Time	SQM	Moon	Phase	Cloudy
20210312	2021	03	12	22:05	20.58	0	0	0.5
20210501	2021	05	01	20:03	20.92	0	0.5	1
20210507	2021	05	07	22:05	20.35	0	0.5	1
20210515	2021	05	15	20:55	20.47	0	0.25	1
20210521	2021	05	21	22:12	19.54	1	0.5	1
20210529	2021	05	29	20:40	20.1	1	0.75	0
20210605	2021	06	05	21:45	20.57	0	0.25	1
20210611	2021	06	11	21:42	19.41	0	0	1
20210626	2021	06	26	21:34	17.22	1	1	1
20210717	2021	07	17	21:52	19.04	1	0.5	0
20210725	2021	07	25	22:30	17.61	1	1	1
20210813	2021	08	13	23:00	21.04	0	0.25	0.5
20210821	2021	08	21	23:00	15.13	1	1	0
20210828	2021	08	28	21:35	20.63	0	0.5	0
20210907	2021	09	07	21:47	21.17	0	0	0
20210911	2021	09	11	21:20	19.96	0	0.25	1
20210918	2021	09	18	21:25	14.69	1	1	0
20211009	2021	10	09	21:40	20.66	1	0.25	1
20211120	2021	11	20	22:03	19.18	1	1	0
20220112	2022	01	12	20:00	19.03	1	0.5	0
20220127	2022	01	27	21:42	20.08	0	0.5	1
20220130	2022	01	30	21:40	20.61	0	0	0
20220210	2022	02	10	21:32	19.59	1	0.5	0
20220227	2022	02	27	22:12	21.18	0	0.25	0
20220320	2022	03	20	20:35	20.72	0	0.75	0.5
20220424	2022	04	24	20:30	20.78	0	0.75	0.25
20220508	2022	05	08	20:31	21.16	0	0	0
20220521	2022	05	21	21:30	21.08		0.25	0
20220701	2022	07	01	21:35	21	0	0	0.75
20220828	2022	08	28	20:52	20.96	0	0	0.5
20221111	2022	11	11	21:12	18.51	1	1	0.5
20230204	2023	02	04	21:55	19.1	1	1	0
20230424	2023	04	24	21:30	21.06	0	0.25	0
20230505	2023	05	05	22:30	16.41	1	1	0
20230523	2023	05	23	21:20	20.58	0	0	0.5
20230618	2023	06	18	19:23	20.76	0	0	0.5

Where:

Moon **Phase** is from 0 (new) to 1 (full)

Moon Present (0-No & 1-Yes)

Cloudy (1=yes; 0.5-partially; 0=no)

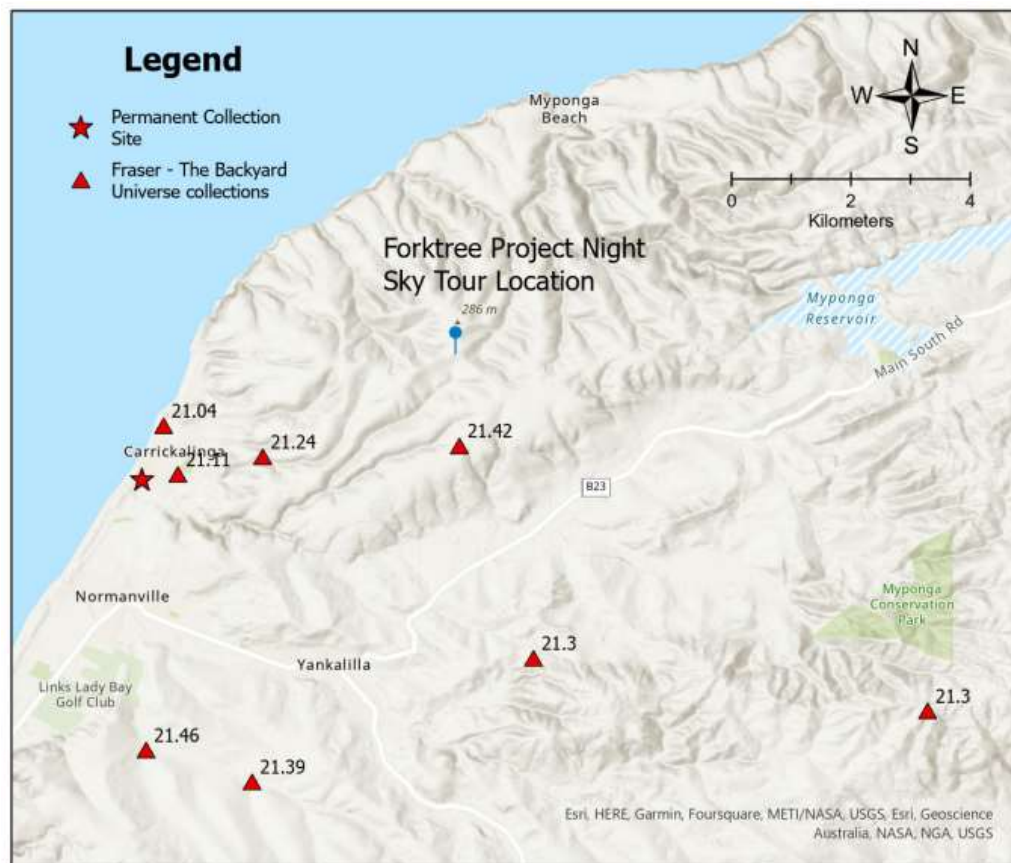
Fraser - The Backyard Universe Data Collection

Lat	Long	Time	SQM	Date	Description
-35.5079524	138.2658446	21:12	21.36	20210303	Anacotilla Springs entrance
-35.4834354	138.2771431	21:16	10:48	20210303	Little Gorge
-35.4731888	138.2921098	21:19	20.31	20210303	Links Lady Bay" resort, upper carpark with full cutoff LEDs
-35.4698393	138.3217514	21:24	21.46	20210303	Intersection Hay Flat Rd + Salt Creek Rd
-35.4746198	138.337705	21:39	21.39	20210303	Intersection Dairy Flat Rd + Torrens Vale Rd
-35.5037637	138.4080451	21:49	21.53	20210303	the late Bill Bradfield's comet-hunting spot at Bald Hills
-35.4639506	138.4393694	21:53	21.3	20210303	Intersection James Track + Kemmis Hill Rd
-35.4560483	138.3800558	22:04	21.3	20210303	Intersection Kemmis Hill Rd + Wenham Rd
-35.4241375	138.3689049	22:11	21.42	20210303	Intersection Smith Hill Rd + Wattle Flat Rd
-35.4257576	138.3392994	22:17	21.24	20210303	Carrickalinga Lookout, Forktree Rd
-35.4211198	138.3243758	22:22	21.04	20210303	Haycock Point carpark, Carrickalinga
-35.4284099	138.3265314	22:25	21.11	20210303	Intersection Davey Rd + Carrickalinga Rd

Forktree Project's Night Skies Tour Location

-35.4106697	138.3683136	23:30	21.56	20230122
-35.4106697	138.3683136	23:00	21.51	20230218
-35.4106697	138.3683136	22:30	21.54	20230219
-35.4106697	138.3683136	23:00	21.33	20230317
-35.4106697	138.3683136	21:00	21.32	20230323

21.452 Average SQM for Night Skies Tour Location just east of Township
Forktree Project is in the Carrickalinga Area boundaries.



Appendix D

Survey results from Aboriginal Astronomy course at University of South Australia

An Example

Carrickalinga Dark Sky Community (CDSC) Survey

Surveyor: ACC-Sharolee Date Time Location: P-Bldg

There is interest within the Carrickalinga community in becoming the first International Dark Sky Community in Australia. International Dark Sky Communities are cities or towns that undertake efforts to enhance the appreciation and value of dark skies. Australia has one International Dark Sky reserve (River Murray) and an International Dark Sky Park (Warrumbungle National Park); however, currently there are no International Dark Sky Communities in Australia. We are interested in your thoughts, on the possibility of Carrickalinga becoming a Dark Sky Community (DSC).

For each of the following statements, please indicate your level of agreement, using the following scale: (1= strongly disagree, 2= disagree; 3=neutral; 4=agree; and 5=strongly agree).

A Carrickalinga DSC would save money on energy, hardware, and maintenance related to street and other night lighting.

SD			N		SA
1	2	3	4	5	

A Carrickalinga DSC would improve human health (e.g. reduce sleep disorders)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would enhance public safety (e.g. reduces night vision capacity, reduces glare)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would provide ecological benefits (e.g maintaining normal predator-prey relationships)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would provide wildlife benefits (e.g reduces disorientation and feeding problems of some species)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote interest in cultural history (eg. Navigation and Aboriginal stories)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote interest in learning about the night sky

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote off-season astro-tourism (e.g. ecotourism, astrophotography)

1	2	3	4	5
---	---	---	---	---

The following questions relate to your personal experience with Carrickalinga and overall Starry Nights

Please rate your level of agreement using the same scale where 1 is "strongly disagree" and 5 is "strongly agree".

On a typical trip to Carrickalinga, I consciously look at the night sky.

1	2	3	4	5
---	---	---	---	---

I have no interest in attending a night sky viewing /astronomy event on the Carrickalinga beach.

1	2	3	4	5
---	---	---	---	---

Carrickalinga has a special 'sense of place' for me.

1	2	3	4	5
---	---	---	---	---

I have a sense of awe when I experience natural night skies.

1	2	3	4	5
---	---	---	---	---

I feel the Carrickalinga night sky is exceptional compared to other places.

1	2	3	4	5
---	---	---	---	---

The night skies are irrelevant to my personal quality of life.

1	2	3	4	5
---	---	---	---	---

What is your relationship to Carrickalinga? Check all that apply

Carrickalinga Resident

☐
☐
☒

Visitor (returning)

Carrickalinga Property Owner

Yankalilla Council Business Owner

First time visitor

Astronomy Enthusiast

☐
☐
☐

Demographic Information

Please circle the value that most closely represents you:

Age Groups 18-----25-----30-----35-----40-----45-----50-----55-----60-----65-----70+

Annual household Income before Tax

25,000-----50,000-----100,000-----150,000-----200,000+

Sex Female Male Prefer not to identify:

Education < Secondary School Secondary School

Bachelors Master PhD

TAFE qualification

Some Uni

What would you like to know more about (if any)?

Night sky viewing/astronomy

Viewing wildlife at night

Aboriginal Cosmos

☒
☒
☒

Light pollution effects

Ways to reduce light pollution

Ways to reduce light pollution

☒
☒
☒

Appendix E

Survey results from the Farmer's Market in Normanville

An Example

Carrickalinga: Do we want Dark Sky Community (DSC)?

There is interest within the Carrickalinga community in becoming the first International Dark Sky Community in Australia. International Dark Sky Communities are cities or towns that undertake efforts to enhance the appreciation and value of dark skies. Australia has one International Dark Sky reserve (River Murray) and an International Dark Sky Park (Warrumbungle National Park); however, currently there are no International Dark Sky Communities in Australia. We are interested in your thoughts, on the possibility of Carrickalinga becoming a **Dark Sky Community (DSC)**.

Thank you for your willingness to complete the survey. It will take you approximately 5 minutes. By completing this survey you are indicating that you have read and understood the Participant Information Sheet and give your consent to be involved in the research.

(1) For each of the following statements, please indicate your level of agreement, using the following scale: (1= strongly disagree, 2= disagree; 3=neutral; 4=agree; and 5=strongly agree).

A Carrickalinga DSC would save money on energy, hardware, and maintenance related to street and other night lighting.

SD			N		SA
1	2	3	4	5	

A Carrickalinga DSC would improve human health (e.g. reduce sleep disorders)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would enhance public safety (e.g. reduces night vision capacity, reduces glare)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would provide ecological benefits (e.g. maintaining normal predator-prey relationships)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would provide wildlife benefits (e.g. reduces disorientation and feeding problems of some species)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote interest in cultural history (eg. Navigation and Aboriginal stories)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote interest in learning about the night sky

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote off-season astro-tourism (e.g. ecotourism, astrophotography)

1	2	3	4	5
---	---	---	---	---

I would support the designation of Carrickalinga as a DSC

1	2	3	4	5
---	---	---	---	---

The following questions relate to your personal experience with Carrickalinga and overall Starry Nights

(2) Please rate your level of agreement using the same scale where 1 is "strongly disagree" and 5 is "strongly agree."

On a typical trip to Carrickalinga, I consciously look at the night sky. .

SD				N			SA
1	2	3	4	5	NA		

I have no interest in attending a night sky viewing /astronomy event on the Carrickalinga beach.

1	2	3	4	5	NA
---	---	---	---	---	----

Carrickalinga has a special 'sense of place' for me.

1	2	3	4	5	NA
---	---	---	---	---	----

I have a sense of awe when I experience natural night skies.

1	2	3	4	5	NA
---	---	---	---	---	----

I feel the Carrickalinga night sky is exceptional compared to other places.

1	2	3	4	5	NA
---	---	---	---	---	----

The night skies are irrelevant to my personal quality of life.

1	2	3	4	5	NA
---	---	---	---	---	----

(3) What is your relationship to Carrickalinga? Check all that apply

Carrickalinga Resident

☒
☐
☐

Visitor (returning)

Carrickalinga Property Owner

Yankalilla Council Business Owner

First time visitor

Astronomy Enthusiast

(4) Demographic Information

Please circle the value that most closely represents you:

Age Groups 18-----25-----30-----35-----40-----45-----50-----55-----60-----65-----70+

Annual Household Income before Tax

25,000-----50,000-----100,000-----150,000-----200,000+

Sex Female Male Prefer not to identify

Education < Secondary School Secondary School TAFE qualification Some Uni

Bachelors Master PhD

What would you like to know more about (Please tick all that apply)

Night sky viewing/astronomy

☒
☒
☒

Light pollution effects

Viewing wildlife at night

Ways to reduce light pollution

Aboriginal Cosmos

Weather for Night sky viewing

☒

Appendix F

District Council of Yankalilla Consultation Report



Name of Project: Dark Sky Lighting Policy

Who are the people or organisations who are most likely to be interested in or impacted by the decisions we make?

1. Carrickalinga Ratepayers Association	2. Carrickalinga Ratepayers
3. Carrickalinga Residents	4.
5.	6.
7.	8.

DO WE NEED TO CONNECT WITH THE COMMUNITY? And if so, why?

The following short survey helps us decide if we need to connect with the public regarding the problem that needs to be solved or decision that we are going to make. We must consider the questions carefully before answering them.

Survey 1 - Do we engage?

1. Is community engagement/consultation required by legislation in your project?

Yes		No	X
-----	--	----	---

If we answered 'yes' to the above question, then we are required to plan and implement community engagement activities for this project. If you answered 'no' then please continue with survey 2.

Survey 2 - Do we engage?

1. Is there already an expectation, within council or the community, that the project will involve community engagement?

Yes	X	No	
-----	---	----	--

2. Can the community influence the outcome of your project?

Yes	X	No	
-----	---	----	--

3. Is there staff time and budget already allocated or available to support the engagement activities?

Yes	X	No	
-----	---	----	--

If we answered 'yes' to **two or more** of the above questions, then it is recommended that we plan and implement community engagement activities for this project. If we answered 'no' to **two or more** of the above questions, then we may need to consider carefully whether it is appropriate to engage with the community on this project. There will be times when a well-executed communications plan is a more appropriate tool for our project and a more efficient use of Council's resources.

CALCULATOR: DETERMINING HOW WE ARE GOING TO CONNECT WITH THE COMMUNITY ON EACH DECISION WE MAKE

Questions	Really Low	Low	Moderate	High	Super high
1. What is the level of difficulty/complexity for Council in making the decision or addressing the problem?				X	
2. How important are the potential impacts of the decision to our community as a whole? (social, environmental, economic)		X			
3. How much do the people most likely to be affected care about the decision to be made?					X
4. What is the potential for community outrage in relation to the final decision?				X	
5. How much engagement do the people in our community appear to want ?			X		
6. How big is the gap between what we know already (via customer service requests, previous consultation/feedback received, inclusion in existing plans) and what we need to know to be able to make the best decision?			X		
Count number of checks in each column		1	2	2	1
Multiply number of checks by the weight	x1	x2	x3	x4	x5
Enter column score		2	6	8	5
Add total of all five column scores	21				
Divide total score by the number of questions	21 /6 = 3.5				
Average score	3.5				

We scored -

☐

1-2 Very low to low

Informing the community about the decision that will or has been made may be sufficient, unless there are legislative requirements in which case **consult**.

*For informing, refer to **menu items with (I)** on the Communication & Listening Tools Menu such as In the Loop, Facebook pages, and email list subscribers. Also consider ways to **communicate directly with those most affected** by the decision, if relevant.*

☐

2-3 Low to Moderate

We will at least **consult** with the community, providing them with options to consider when seeking feedback.

*For consulting on proposals, refer to **menu items with (C)** on the Communication & Listening Tools Menu such as written submissions, interviews, surveys, onsite pop ups, online surveys or quick polls. Consider ways to **consult directly with those most affected** by the decision and consider the need to use a mix of paper-based, face-to-face or digital tools. Remember to **inform** people about the final decision that was made and why.*

☒

3-4 Moderate to High

We will **consult** or **proactively involve people in problem solving** during the decision-making process.

*Refer to **menu items with (C) or (PS)** on the Communication & Listening Tools Menu such as interviews, surveys, working with existing groups, roundtables, public forums and online discussion forums. Consider ways to **connect directly with those most affected** by the decision and consider if there is a need for a mix of paper-based, face-to-face or digital tools. Remember to **inform** people about the final decision that was made and why.*

☐

4-5 High to Very High

At a minimum we should provide opportunities to **proactively involve people** in the problem-solving process.

*Refer to **menu items with (PS)** on the Communication & Listening Tools Menu such as interviews, working with existing groups, roundtables, public forums, online mapping and online discussion forums.*

*Consider ways to **connect directly with those most affected by the decision** and consider if there is a need for paper-based, face-to-face or digital tools. Remember to **inform** people about the final decision that was made and why.*

MENU

PAPER-BASED COMMUNICATION TOOLS

☒ IN THE LOOP

Monthly Council publication, 4 pages full colour, option to upgrade to 8 pages, 5,400 circulation within Yankalilla Regional News (I) \$ ^

☐ YANKALILLA REGIONAL NEWS

Monthly local publication, letters to the editor, paid advertising opportunities, articles (I) (PIP) \$\$ ^^

☐ THE TIMES/ADVERTISER

Editorial options, paid advertising/notifications (I) \$\$\$ ^^

☒ RATEPAYER MAIL OUT (To Carrickalinga Township Ratepayers)

Letters direct to our 5,500 ratepayers, can be sent to specific postcodes if required (I) \$\$\$ ^^

☐ RESIDENT 'LETTERBOX' DROP

Letters, flyers, postcards to everyone in the Yankalilla township with a mail box, and PO Boxes across the District. Caution: Limited due to lack of mailboxes at many properties and limited knowledge of PO Box ownership. (I) \$\$ ^^

☐ VIA RATES NOTICES

Quarterly distribution of rates notices to all ratepayers. Company who provide this charge for additional printing/folding and weight limitations (I) \$\$ ^^

☐ DISPLAYS

Information displayed or made available at Council locations including library, civic centre, community centre and Visitor Information Centre. (I) \$\$ ^^

☐ LOCAL 'DROP SPOTS'

Circulation information via frequently visited community locations such as Post Offices and General Stores, cafes, bakeries, community notice boards. (I) \$ ^^

DIGITAL COMMUNICATION TOOLS

☒ COUNCIL WEBSITE

Announcements, Contact Us, Council meeting agendas, minutes and reports (I) \$ ^

☒ FACEBOOK PAGES

4 Council run pages - District Council of Yankalilla (2,200+ followers), Community Centre (580+), Library (390+) and Visit Fleurieu Coast (8.2k+) (I) \$ ^

☐ MAILING LIST SUBSCRIBERS

1300+ people subscribed via website to receive email information about community consultation, employment, In the Loop and Latest News (I) \$ ^^

☐ YOUR SAY YANKALILLA SUBSCRIBERS

800+ identified & registered users of YourSay Yankalilla, Council's online engagement hub (I) \$ ^^

☐ COMMUNITY RADIO

Regular broadcasting by CEO to provide up to date information relating to Council activities (I) \$ ^^

- SIDES -

- ☐ INCOMING CALLS 'ON HOLD' MESSAGE (I) \$ ^
- ☐ EMAIL SIGNATURES (I) \$ ^
- ☐ TWITTER POST 4.4K PEOPLE (I) \$ ^
- ☐ CEO/VISITOR CENTRE INSTAGRAM POST (I) \$ ^
- ☐ LINKEDIN POST (I) \$ ^
- ☐ VIDEO INTROS (I) \$ ^^

DIETARY REQUIREMENTS

- ☐ (PIP) Public Initiated Participation where people in the **community raise topics** of importance to them;
- ☒ (PS) Proactively involving people in **problem solving**;
- ☒ (C) **Consulting people on proposals** regarding upcoming decisions that Council is planning to make;
- ☐ (I) **Informing people about decisions** that Council has made or is about to make.



\$ Affordable
\$\$ Some budget required
\$\$\$ Significant cost

^ 0-3 people hours
^^ 3-10 people hours
^^^ 11+ people hours

FACE-TO-FACE LISTENING TOOLS

☐ 'BACK OF THE UTE' CHATS

Informal, impromptu, and part of the Elected Members existing social networks. These informal chats help Elected Members keep their ear to the ground as to what's happening in the community. (I) (C) (PS) (PIP) \$ ^

☐ MONTHLY LISTENING POSTS

Elected Members being available at a particular time and visible place each month to listen to issues that are important to people in the community. Eg. Ruth's Kerbside Chats in Normanville. (PIP) \$ ^^

☐ WORKING GROUPS

People who are interested or affected by a topic, project or decision being actively involved in shaping the outcome over a period of time. (PS) \$ ^^

☐ INTERVIEWS

One to one documented conversations (in person or via telephone) with people who have an interest or will be impacted, using a structured set of questions to collect input. Eg. Aged Friendly Action Plan. (C) (PS) \$ ^^

☐ 'ONSITE' POP UPS

Undertaking engagement activity at a relevant location relevant. Can include any number of other engagement tools being used to communicate or listen whilst there. Eg Bungala Park. (I) (C) (PS) \$\$ ^^

☐ PUBLIC FORUMS

Holding a meeting where people can find out information, ask questions and provide input through conversation with Council or others in the community E.g. SA Water (I) (C) (PS) \$ ^^

☐ ROUNDTABLES & FOCUS GROUPS

Inviting people with an active interest in a decision or problem to be part of a meeting where detailed and robust conversation occurs to inform decision making. Eg. Normanville Beach Access (C) (PS) \$ ^^

☒ WORKING WITH EXISTING GROUPS

Working with peak bodies, resident and business associations, and other similar organisations to seek community leader input in to decision making and problem solving. (C) (PS) (PIP) \$ ^^

Carrickalinga Ratepayers Association

☐ INDIVIDUAL/GROUP DEPUTATIONS

People attending a Council meeting to present an issue of concern to the Elected Members, which is within the power of Council to consider. (C) (PS) (PIP) \$ ^

Minimum 42 days consultation period

Level 3 as per our consultation policy

© District Council of Yankalilla 2019

DIGITAL LISTENING TOOLS

☐ ONLINE 'QUICK POLLS'

Single question, immediate insight, quick and targeted tool. Controlled environment - participants cannot interact. (C) (PS) \$ ^

☒ ONLINE SURVEY

Opportunity to voice opinions in a convenient and guided way. Controlled environment, participants cannot interact. (C) (PS) \$ ^^

☐ ONLINE IDEAS BOARD

This "virtual suggestion box" is a way for people to share ideas or inspiration. Ideas can include images or media for participants like and comment directly. (PIP) \$ ^

☐ ONLINE DISCUSSION FORUM

A safe and interactive space for registered users to discuss and debate projects or upcoming decisions. Provides deeper engagement for passionate stakeholders. (C) (A) \$ ^^

☐ ONLINE MAPPING SUGGESTION TOOL

Gather feedback and photos directly on a map with a simple "pin" drop. Geospatial maps offer participants a fun way to engage and see their contribution on a map. (C) (A) \$ ^^

☐ SOCIAL MEDIA COMMENTARY

General commentary and community sentiment captured from comments made on posts shared on Facebook, LinkedIn, Twitter and Instagram. (C) (PS) (PIP) \$ ^

PAPER-BASED LISTENING TOOLS

☐ WRITTEN SURVEYS

Encourage people to voice their opinions in a convenient and guided way through a paper based survey. Could be mailed to residents, contained within print media, etc. (C) \$\$ ^^

☒ WRITTEN SUBMISSIONS

Traditional method of raising concerns regarding (or showing support of) Council initiatives. Limits to only the highly engaged who are willing to take time to write a letter. (C) (PS) (PIP) \$ ^

Please remember to not bite off more than you can chew. Choosing everything on the menu isn't going to necessarily give you the best value. It might in fact give you indigestion.

Dark Sky Community CARRICKALINGA



Community Engagement Report

15 June 2022

SUMMARY

Community Engagement on the concept of Carrickalinga becoming a Dark Sky Community and the Draft Dark Sky – Carrickalinga Policy was conducted from 29 September – 13 November 2022, following Council's endorsement of the Community Engagement Plan at its meeting on 16 August 2022.

The Community Engagement process was undertaken by Council staff and supported by the CRA. It included the following elements:

1. Submissions open to the general public online via Council's community engagement website Your Say Yankalilla (www.yoursayyankalilla.com.au).
2. Written submissions accepted via email to council@yankalilla.sa.gov.au or posted to PO Box 9, Yankalilla SA 5203.

Supporting information was provided throughout the consultation process. Prior to submitting their views the Community were encouraged to:

3. View the YouTube video of Professor Chris Daniels explaining the initiative via www.yoursayyankalilla.com.au
4. Read the Dark Sky Lighting – Carrickalinga Fact Sheet.
5. Read the Frequently Asked Questions resource.
6. Read the Draft Dark Sky Lighting – Carrickalinga Policy.

Promotion of the Engagement was adequately planned and executed, with particular success driving participants to the Your Say Yankalilla site seen via various Facebook clicks throughs (123 site visits).

Worth noting is that an InDaily Regional News article regarding the Dark Sky Carrickalinga initiative was published on Monday 10 October and drove 45 visits to the Engagement project at Your Say Yankalilla. The online link to the article is provided here:

<https://indaily.com.au/events/regional-news/2022/10/10/carrickalinga-looking-to-become-australias-first-dark-sky-community/>

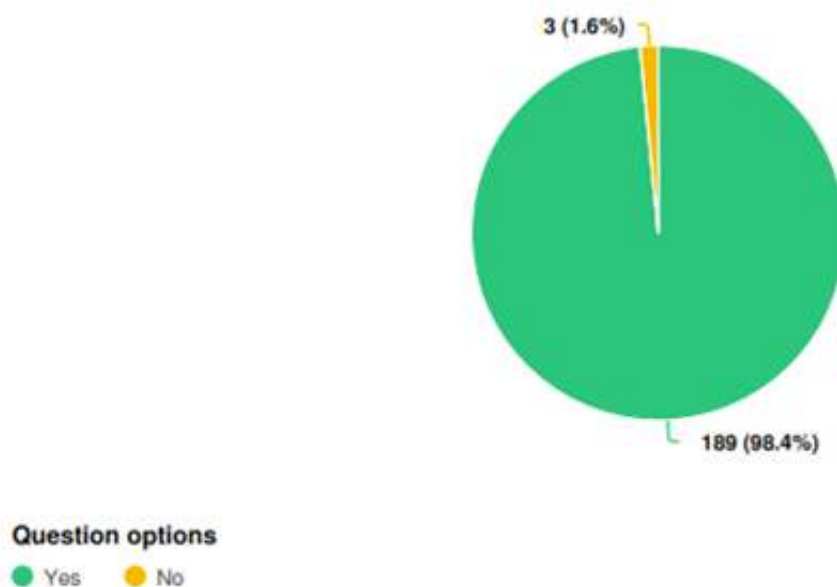
Google links drove 6 visits to Your Say Yankalilla, Council's website drove 29 visits to the site and visits were recorded from email clicks throughs.

The Engagement was simple in nature, asking the community of Carrickalinga and the broader District to provide their feedback with two main questions in mind:

7. How satisfied are you with the concept of Carrickalinga becoming a Dark Sky Community?
8. How satisfied are you with the Draft Dark Sky Lighting Policy for Carrickalinga?

Excellent engagement online with 116 visitors to the site viewing Chris Daniels video and over 70 visitors downloading both the policy document and the FAQs to have a read.

Please confirm you have watched the Carrickalinga Dark Sky Lighting Policy Video?

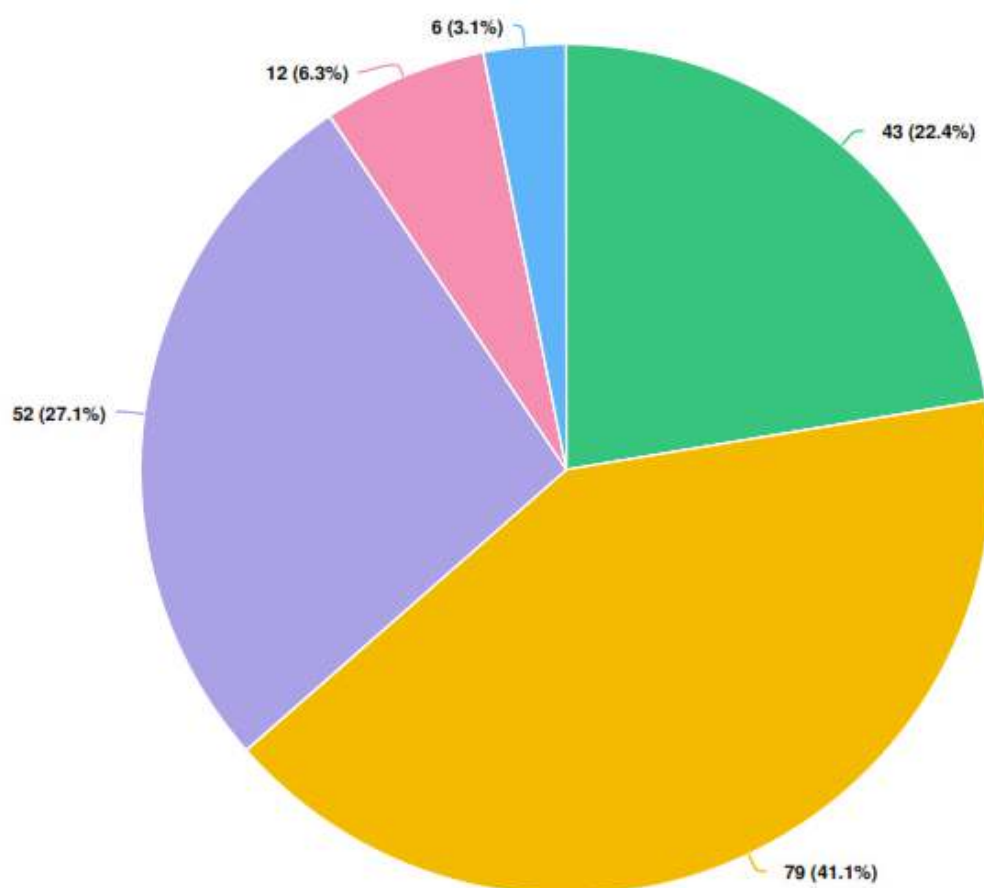


Online Survey

The online survey received 192 responses. The results are provided below:

Over 60% respondents live or own property in Carrickalinga and another 27% live or own property in the District.

Select which statement best describes you?

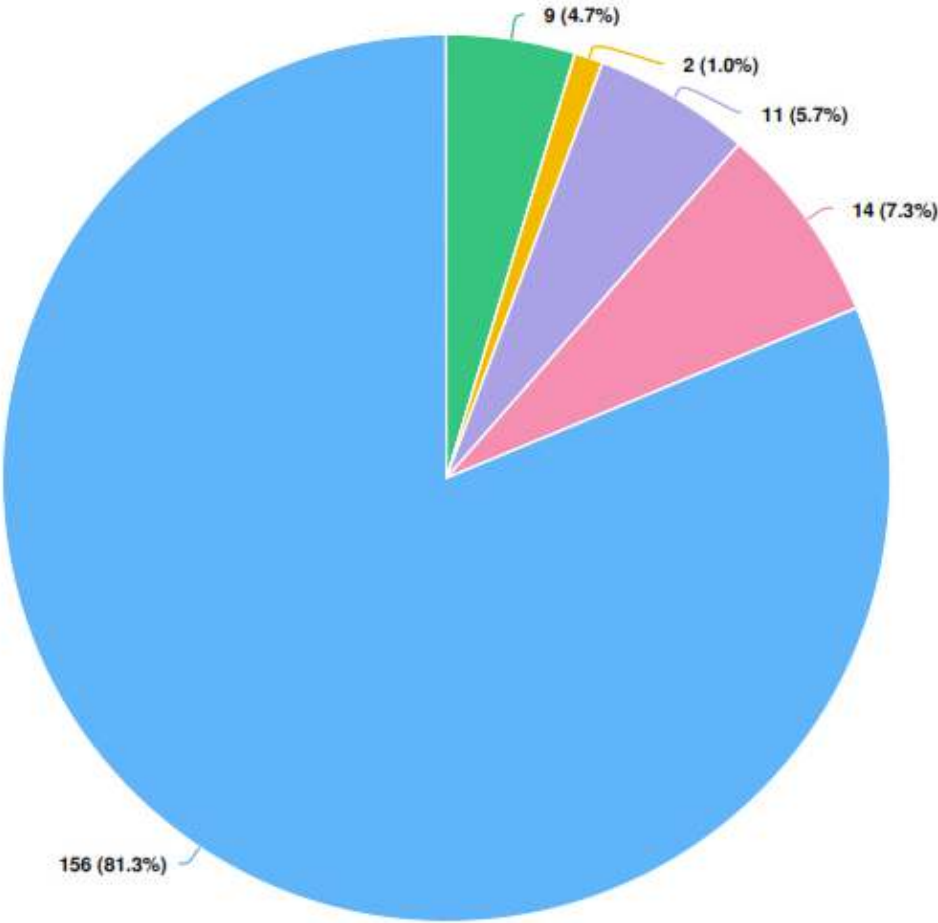


Question options

- I live in Carrickalinga
- I own a property in Carrickalinga
- I live in or own a property elsewhere in the District Council of Yankalilla area
- I visit Carrickalinga
- Other (please specify)

Over 80% are 'satisfied' with the concept of Carrickalinga becoming a Dark Sky Community.

How satisfied are you with the concept of Carrickalinga becoming a Dark Sky Community?

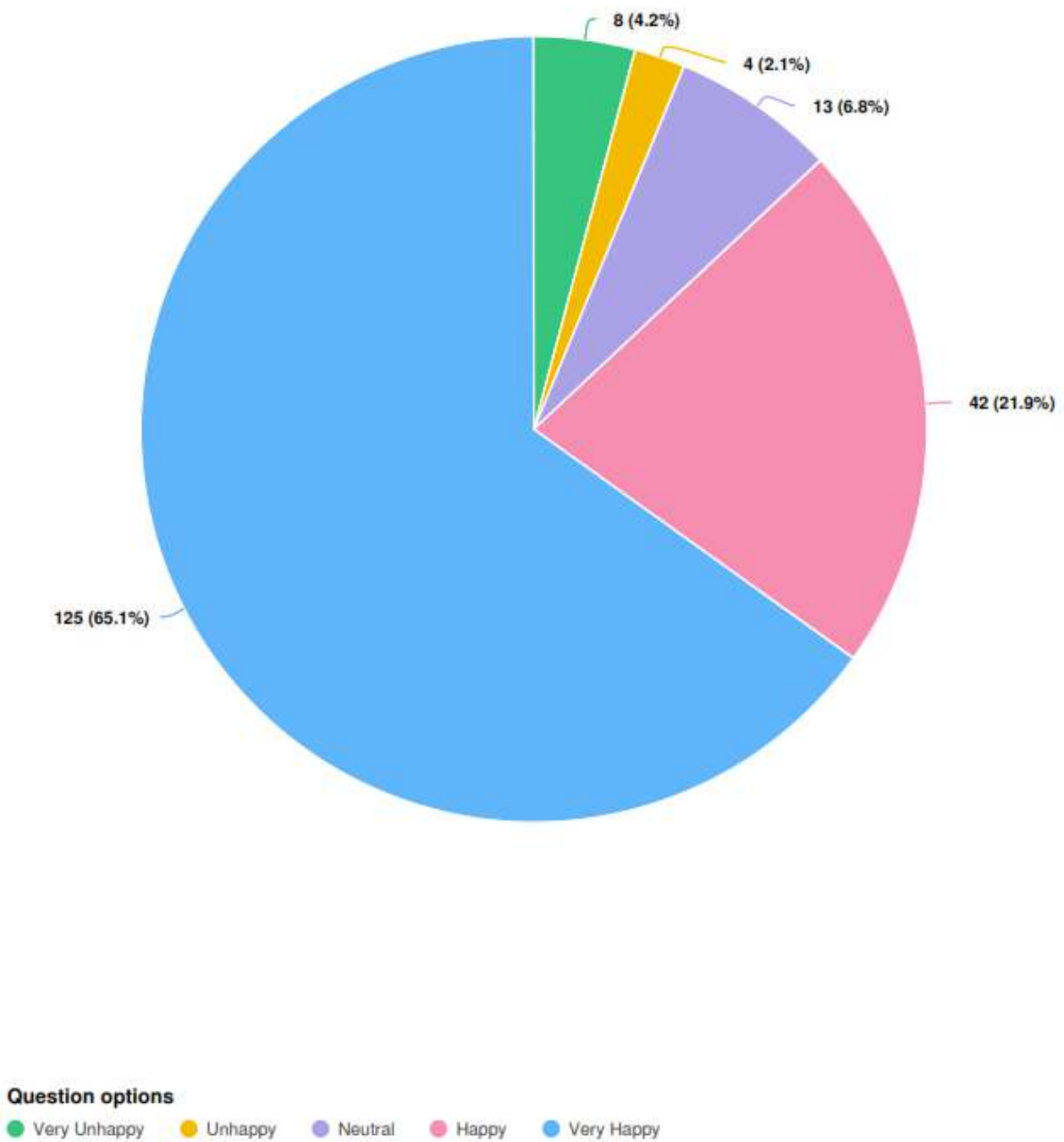


Question options

- Very Unhappy
- Unhappy
- Neutral
- Happy
- Very Happy

Over 85% of respondents are happy or very happy with the draft Dark Sky Lighting - Carrickalinga Policy.

How satisfied are you with the Draft Dark Sky Lighting Policy for Carrickalinga?



Written submissions – General feedback

Summary of comments

Within the survey, question 10 asked *'Do you have any comments or feedback?'*

The bulk of commentary provided here has been constructive, which has allowed for some of the concerns raised to be addressed within the report to Council at its December 2022 meeting and put forward here for consideration as this project progresses.

Examples of concerns raised:

- *"In addition to my survey submission I'd like add that for such a positive project in the Dark Sky Community campaign that has so many virtues, it seems incredibly disappointing that the council is offering zero funds to cover any costs associated with such a vitalising community initiative."*
- *"If there is a cost to council, it must not reflect (pun) an increase in annual rates."*
- *"Why is this survey not confidential, this obviously effects its validity."*
- *"I would like more information about the potential costs that may be involved, who will incur these and if we would need to make any changes to our property due to the new policy."*
- *"To be happy with the concept of the dark night policy does not give whole hearted acceptance and support. I would need to hear arguments against and costing arrangements 38 lights to be upgraded is one thing but to want to burden rate payers with more lights to satisfy a few zealous advocates for a dark policy is another."*

A high proportion of responses received were positive in sentiment, with often encouraging commentary to see this project progress. Here are some examples:

- *"Congratulations on this exciting initiative."*
- *"Would be a good draw card for the kind of eco-friendly tourism Yankalilla and the Fleurieu should seek out."*
- *"Please add our strong support for this concept. We would be happy to do whatever is necessary on our own property to support the Dark Sky Lighting Policy and love the lack of street lights in Carrickalinga."*
- *"Beautiful sky down south let's make it an asset!"*
- *"It makes sense for our councils and communities to adopt policies that enhance our natural environment by upgrading and incorporating more modern lighting technology."*

Negative sentiment was received at a lower proportion of within the responses however it was recorded strongly by some survey participants. Here are some examples

- *"I am writing to express my ZERO support for the dark sky lighting policy."*
- *"However I have mild reservations about the impact of tourism that a Dark Sky Community will bring. The control of this needs consideration."*
- *"Do not wish this to go ahead. I am a rate-payer and I am against all proposals."*
- *"Lots of money spent on advertising brochure? Money better spent on other pressing issues like more beach bins, vegetation/planting, parks. So many things! V confusing why this is even an interest for Carrickalinga?! The stars are v apparent in Carri!"*
- *"The night sky at Carrickalinga is already highly visible and this seems like a waste of time and resources."*

Within the responses, there is mention of broadening the coverage of the Policy to other townships across the District:

- *"Looking forward to seeing the policy endorsed (and expanding across the district!)."*
- *"This would be great if this inspired Dark Sky lighting policy in other settlements eg Wirrina/ Second Valley, Rapid Bay. This is a great initiative by the Carri rate payers assoc and hope this will educate will drive change elsewhere to minimise our light pollution."*
- *"I would love to see it extended to other townships in DCY. Well done Carrickalinga Ratepayers Association and DCY!"*
- *"Extend Dark Sky Lighting policy to include Normanville and Yankalilla."*
- *"Would love to see the same thing happen in the Links Lady Bay Area!"*

Written submissions – Draft Dark Sky Lighting – Carrickalinga Policy: Summary of comments

Within the survey, question 9 asked *‘Do you have any suggestions to improve the Dark Sky Lighting – Carrickalinga Policy?’*

A high proportion of responses here were positive towards the content of the Policy and participants were constructive in their suggestions for consideration. Some concerns with were also received that largely focused on clarifying impacts the policy will to private land owners.

Concerns raised:

- *“All for it but the towns must have sight and light for safety and security”*
- *“The light spill from Adelaide clearly does not make this a dark sky community. Any new housing developments (i.e. Lot 300 Brown Road, Carrickalinga) will still have to conform with Australian standards for lighting so the number of streetlights will only increase.”*
- *“I have a dependency for the street lighting located at the bottom of our driveway. I do not want the illumination reduced, however I do not object to a diffuser reducing the up light, providing the down light remains as is.”*
- *“Ensure residents are able to access to affordable alternatives to private property lighting which are sourced in low emission, low energy LED bulbs especially for those with on-site car parking.”*
- *“Suggesting increased tourism to the area seems counterproductive as having tourists drive into the area at night to see the night sky would bring more light.”*

Constructive suggestions for the Policy:

- *“Refer to practical guidance material created for towns around NSW Warrumbungles Night Sky Park. No need to reinvent or develop policy in isolation, it is important to collaborate and learn from interstate jurisdictions that have already developed these policies.”*
- *“If accepted ensure all residents and or land owners receive clear documentation about the policy and how to comply from a personal perspective.”*
- *“If residents are required to replace any or all flood lighting and external lighting at their own cost I do not believe most will feel this to be satisfactory. New developments have been addressed, existing residences have not.”*
- *“No details on costing and operational maintenance.”*

Positive commentary:

- *“Although the night sky can be fairly full of stars, there are too many lights for the best viewing. I would certainly go to Carrickalinga to star watch if the Policy goes ahead.”*
- *“Fabulous idea. Just do it”*
- *“Good idea. Good for environment, good for tourists and photographers.”*
- *“This sounds like genuinely good policy that should be extended to the whole District.”*
- *“I think it is a great initiative. The lights of Adelaide are already encroaching on Carrickalinga and make it less dark than I remember as a boy.”*

Negative commentary:

- *“I’m not sure that with the big projects we have going on at the moment, we should spend admin time and resources on something like this. This could continue as more of a community initiative before we have to change things like streetlights for one location.”*
- *“Do not wish this to go ahead. I am a rate-payer and I am against all proposals.”*
- *“The night sky at Carrickalinga is already highly visible and this seems like a waste of time and resources.”*
- *“Unnecessary waste of rate payers dollars as usual! The roads are atrocious and in desperate need of repair throughout our district”*
- *“Not at this time.”*

Within the responses, again there is mention of broadening the coverage of the Policy to other townships across the District:

- *“I would strongly support Second Valley adopting the same principles.”*
- *“Extend Dark Sky Lighting policy to include Normanville and Yankalilla”*
- *“This would be great if this inspired Dark Sky lighting policy in other settlements eg Wirrina/ Second Valley, Rapid Bay. This is a great initiative by the Carri rate payers assoc and hope this will educate will drive change elsewhere to minimise our light pollution.”*

Appendix G

Consultations Resources for Residents

Dark Sky Lighting Policy – Carrickalinga

The Carrickalinga Ratepayers Association are progressing an application for Carrickalinga to become Australia's first Dark Sky Community.

In order to progress the application, it requires Council to adopt a Dark Sky Lighting Policy.

The Carrickalinga Ratepayers Association and Council are working together, and we invite you to share your views on the draft Dark Sky Lighting Policy.

What is a Dark Sky?

A Dark Sky is a natural night sky unaffected by light pollution.

What is the Dark Skies movement?

It is an international commitment to protect the night skies for present and future generations. For over two decades, the International Dark-Sky Association has managed the award-winning International Dark Sky Places Program.

The movement encourages communities all over the world to upgrade to more efficient and appropriate lighting, to reduce unnecessary lighting, and to value the night skies for their benefits and beauty.

Australia has amazing night skies, such as those of Carrickalinga, and yet these too are being continually degraded by surrounding light pollution.

Becoming a Dark Sky Community will help protect the community and environment from local light pollution and provide inspiration for surrounding areas to protect our spectacular night sky.

What is light pollution?

Light pollution, or artificial light at night, is the presence of unwanted, inappropriate or excessive artificial lighting. Light pollution is one of the most significant changes that humans have made to the natural environment and can have serious consequences for humans, wildlife, ecosystems and our climate. It is a rapidly growing problem around the world.

What is smart lighting?

Lighting is 'smart' when appropriate for the task, and refers to where, when and the amount of light produced. This is better termed 'smart lighting design' where the need, the timing and the minimum requirements for light are assessed.

Smart lighting means that we:



Use **targeted lighting** - light only when and where we need



Use **shielded lights** and direct them downward, avoiding light trespass



Use **energy efficient bulbs** that are no brighter than necessary



Use **warm white** or **amber-coloured bulbs**



Use controls such as **motion sensors** and **dimmers**



Is smart lighting safe?

It is an urban myth that more light is safer. In truth, research finds that well-designed lighting is safer.

Carefully targeted and uniform lighting are critical elements of night-time safety. Bright and glary lights are shown to detract from safety.

'Dark sky' does not mean 'dark ground'. Smart lighting means you can have a dark sky without losing light on the ground.

Why become a Dark Sky Community?

There are human health, ecological health and economic benefits in protecting the natural night sky.

The human health benefits are many and range from better sleep to physical and mental well-being. Plants and animals, and indeed whole ecosystems, have evolved with the natural day/night cycles and so keeping this as natural as possible is of great benefit for wildlife, and essential for the survival of many species.

Economic benefits are also very clear, with energy savings translating directly into monetary savings. This also helps with mitigation of climate change by reducing energy production emissions into the atmosphere. Investment in the future of dark skies is valuable for many reasons.

Why Carrickalinga?

The "Made by Nature" Fleurieu Coast community of Carrickalinga has only 38 streetlights. The upgrade of these lights can be achieved for little cost and effort and the Carrickalinga Ratepayers Association who are driving this proposal and will be responsible for all activities required to receive a Dark Skies Communities Accreditation, including the cost of light shields, and working with Council on the development of a Dark Sky Lighting Policy.

Carrickalinga could then become the first Dark Sky Community in Australia. With less than forty such 'communities' in the world at this stage, this would be a great accomplishment indeed.

This initiative of the Carrickalinga Rate Payers Association aims to reduce light pollution, improve human and environmental health, and save both money and energy while reducing greenhouse gas emissions, so residents and visitors alike can enjoy the night skies into the future.

Stargazing brings joy and wonder to all of us in different ways and the starry skies of the Fleurieu Peninsula are precious.



Bortle Scale 1- Excellent 9 - City Sky

The Draft Policy

The draft Dark Sky Lighting Policy is based on the requirements of the International Dark Sky Community Program Guidelines.

This policy shall apply to the Designated Area of Carrickalinga Township who through the Carrickalinga

Ratepayers Association are actively seeking accreditation from the International Dark-Sky Association as a Dark Sky Community.

Council, under this Dark Sky Lighting policy aims to;

- Ensure that Council, other Government bodies and private landholders within an area designated understands how they can assist attaining, preserving, and promoting the Dark Sky Community concept.
- Ensure all new public lighting within an area designated meets the standards and requirements.
- Retrofit existing outdoor public lighting within an area designated to ensure it meets the standards and requirements.
- Confirm that the costs for delivery of infrastructure works are to be borne by the groups requesting the Dark Sky infrastructure, noting that in this case, the Carrickalinga Residents Association have offered to bear these costs.

The Policy aims to minimise the light pollution and promote 'Dark Sky friendly lighting' by considering the following principles;

- Outdoor public lighting should only be installed when deemed necessary and should only be activated when needed,
- All outdoor lighting should be directed downwards so that light spill is avoided,
- Fittings should include light shields so that light it is directed downwards,
- The intensity of outdoor lighting should be appropriate for its intended use,
- Coordinated colour temperature (CCT) of lighting shall be less than 3000 K.

The Draft Dark Sky Lighting Policy does not seek to limit development or remove existing lighting, however it does outline a minimum standard to provide adequate lighting under current Australian standards while utilising Dark Sky Friendly principles.

Council is seeking community feedback on the Draft Dark Sky Lighting Policy before the Council consider formally adopting the policy.

You can find the full policy, more information and complete the online survey via www.yoursayyankalilla.com.au, send an email to consultation@yankalilla.sa.gov.au or write to The District Council of Yankalilla PO Box 9, Yankalilla.

Consultation Opens Thursday 29 September and closes Sunday 13 November 2022.

Postcard / Handout



Front Image of Southern Cross

Take Action!

**Light Pollution affects us all.
5 ways you can make a difference!**

1. Install lighting only when and where it's needed.
2. Use energy saving features such as timers, dimmers and motion sensors on outdoor lights.
3. Make sure your lighting is shielded so light shines down, not up. Encourage good lighting at your workplace, too.
4. Educate your friends and neighbors about the importance of good lighting for our health, economy and environment.
5. Join IDA and visit darksky.org for more information and free resources.

Front silhouette photo by @JGraeme
Sunset photo by Mark Earl

Support Dark Skies in Carrickalinga

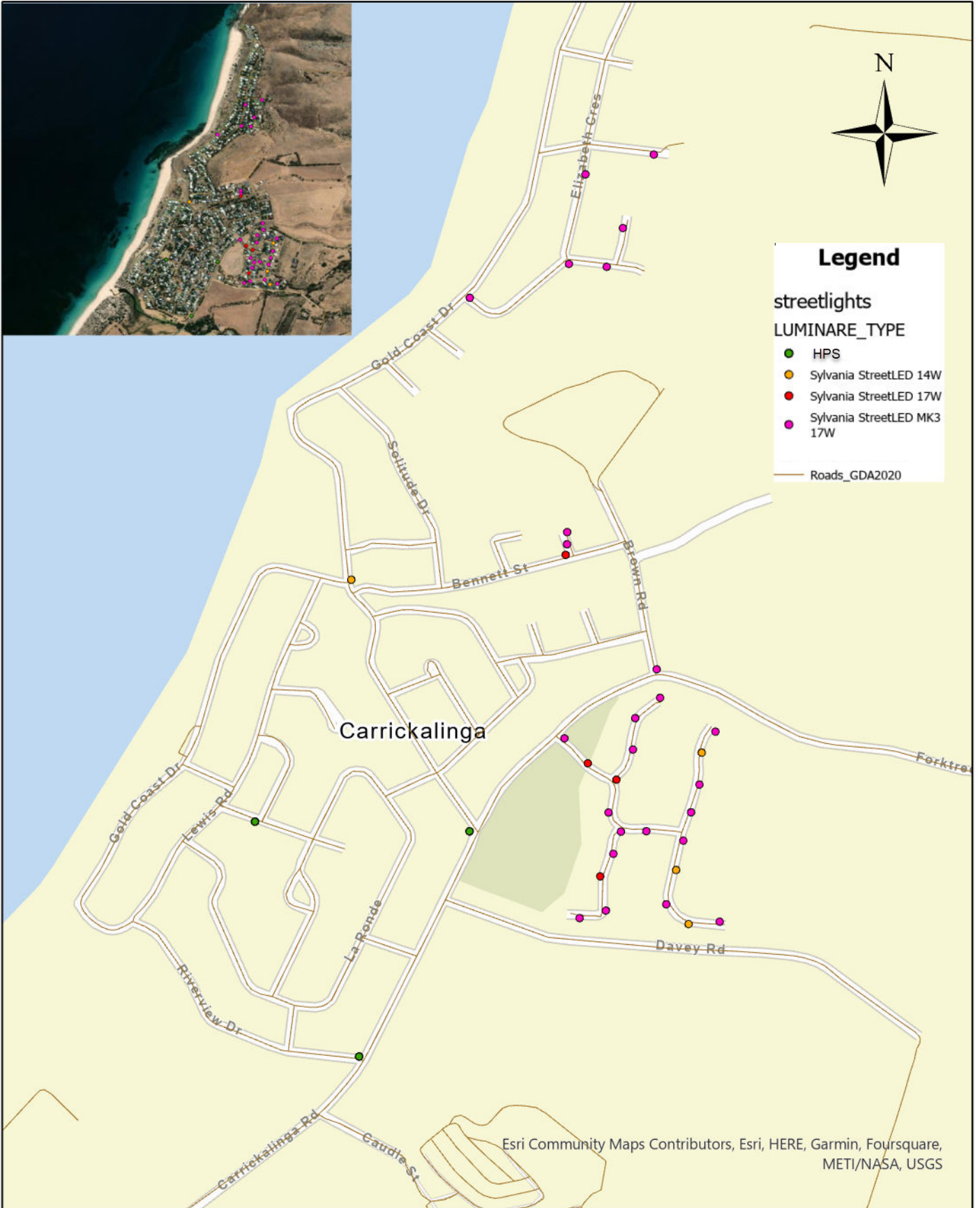
For more information
contact us via email

CarrickalingaDarkSky@gmail.com

Back Dark Sky Information

Appendix H

Carrickalinga Streetlights

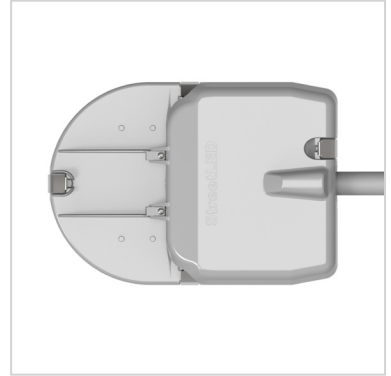
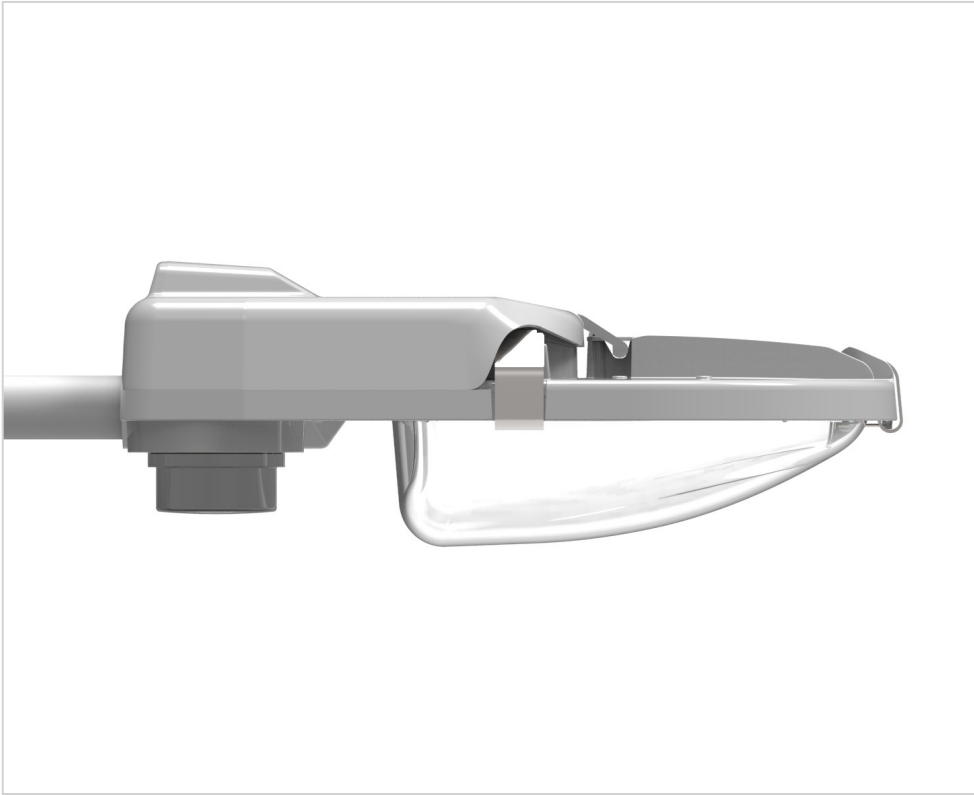


South Australia Power Network Data for Carrickalinga Streetlighting

Count	LATITUDE	LONGITUDE	CUSTOMER_NUMBER	STOMER_T	TARIFF	LAMP_TYPE	LUMINARE_TYPE	CCT	CCT*	ISACTIVE
1	-35.426994	138.323203	DISTRICT COUNCIL OF YANKALILLA	COUNCIL	PLC	LED17	<Null>	4000	4038	1
2	-35.425517	138.328695	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4059	1
3	-35.42625	138.329618	DC OF YANKALILLA	COUNCIL	SAPN	LED17	Sylvania StreetLED 17W	4000	4069	1
4	-35.427331	138.330804	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
5	-35.422702	138.324912	DISTRICT COUNCIL OF YANKALILLA	COUNCIL	SAPN	LED17	Sylvania StreetLED 14W	4000	4181	1
6	-35.427171	138.329697	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4208	1
7	-35.427851	138.330677	DISTRICT COUNCIL OF YANKALILLA	COUNCIL	SAPN	LED17	Sylvania StreetLED 14W	4000		1
8	-35.42577	138.331131	DISTRICT COUNCIL OF YANKALILLA	COUNCIL	SAPN	LED17	Sylvania StreetLED 14W	4000		1
9	-35.416464	138.329732	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4194	1
10	-35.417151	138.329445	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4096	1
11	-35.415512	138.32907	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4096	1
12	-35.41516	138.330281	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
13	-35.422262	138.328717	DC OF YANKALILLA	COUNCIL	SAPN	LED17	Sylvania StreetLED 17W	4000	4308	1
14	-35.422074	138.328741	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4198	1
15	-35.421858	138.328743	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4178	1
16	-35.42846	138.330503	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
17	-35.426829	138.330942	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
18	-35.425396	138.331375	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
19	-35.428571	138.329431	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
20	-35.428769	138.331451	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
21	-35.426337	138.33109	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
22	-35.427965	138.32933	DISTRICT COUNCIL OF YANKALILLA	COUNCIL	SAPN	LED17	Sylvania StreetLED 17W	4000		1
23	-35.43116	138.32505	DISTRICT COUNCIL OF YANKALILLA	COUNCIL	SLUOS	S100	<Null>	2200	2170	1
24	-35.425959	138.32911	DC OF YANKALILLA	COUNCIL	SAPN	LED17	Sylvania StreetLED 17W	4000	4036	1
25	-35.428811	138.330899	DISTRICT COUNCIL OF YANKALILLA	COUNCIL	SAPN	LED17	Sylvania StreetLED 14W	4000		1
26	-35.425716	138.329911	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4306	1
27	-35.425158	138.329951	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4096	1
28	-35.424798	138.330392	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4130	1
29	-35.427163	138.330149	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4124	1
30	-35.428705	138.328964	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
31	-35.427565	138.329563	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
32	-35.417101	138.328775	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
33	-35.417701	138.327015	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4094	1
34	-35.426833	138.329477	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000		1
35	-35.427166	138.327011	DC OF YANKALILLA	COUNCIL	SLUOS	S100	<Null>	2200	2069	1
36	-35.424292	138.330332	DC OF YANKALILLA	COUNCIL	PLC	LED17	Sylvania StreetLED MK3 17W	4000	4129	1

*CCT values measured by CRA June 2023 with OPPL Light Master 3

SYLVANIA STREETLED MK III



SYLVANIA

The smart choice for urban roads

Engineered and crafted in Australia, the StreetLED MKIII is a high performance luminaire designed specifically to meet Australian/New Zealand minor road lighting requirements.

The optical system with LED light source is optimised to provide the maximum spacing complying with AS1158-3.1 Category P.

The optical chamber sealed to IP66 ingress protection and the self-cleaning visor minimises light loss due to dirt accumulation, reducing maintenance and resulting in a high energy efficient luminaire.

Perfect for one-for-one replacement for legacy fittings including 70W HPS, 80W MV, 32/42W CFL, 2 x 14W T5, 2 x 24W T5.

SCO

IK 06

OPTIC &
CONTROL GEAR

IP 66



AERO

IK 07

CONNECTION
CHAMBER

IP 24



URBAN &
RESIDENTIAL
STREETS



BIKE &
PEDESTRIAN
PATHS



SQUARES &
PEDESTRIAN
AREAS



CAR PARKS



LARGE
AREAS



ROADS &
MOTORWAYS

MAIN APPLICATIONS

- Urban and residential streets
- Bike and pedestrian paths
- Squares and pedestrian areas
- Car parks
- Large areas
- Roads and motorways

KEY ADVANTAGES

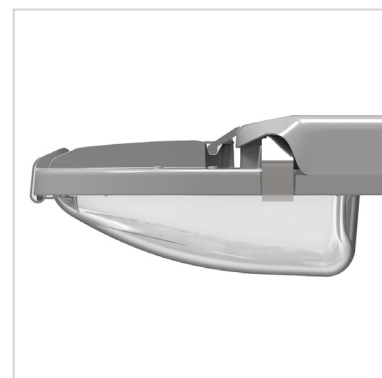
- High performance roadway luminaire, designed specifically to meet Australian/New Zealand Road Lighting Standards, complying with both AS/NZS 60598.2.3 & AS/NZS TS 1158.6
- The optics and LED light source are optimised to provide maximum spacings for compliance with AS1158-3.1 Category P
- Optical chamber sealed to IP66 ingress protection
- IK06 (SCO) IK07 (AREO)
- Self-cleaning visor minimises light loss due to dirt accumulation, resulting in a highly energy efficient and low maintenance luminaire
- CRI 70
- Ambient temperature 40°C
- 20 year design life
- Available in Colour Temperature of 4000K standard, 3000K & 2200K optional
- VEET approved (applies to certain models)

OPTIONS:

- Polyester powdercoat finish in various RAL and DULUX colours
- NEMA PE cell
- Visor options - Aeroscreen and standard
- Anti-Glare visors and louvers
- 5° Tilt Adjustment Adapter



Toggle latch for tool-less entry



Semi cut-off self cleaning visor



NEMA 7 pin base for smart city (IoT) readiness



5° Tilt Adjustment Adapter for Spigots. Ensures that correct tilt can be achieved if the original pole outreach angle is incorrect.

SCS is focused on Smart Control technologies, delivering solutions to clients that enable these Smart LED luminaires to become smarter.

The equipped NEMA sockets on the luminaire connects a Smart Light Point Controller/ Node with an easy twist and lock mechanism. The Light Point Controllers enables these luminaires to be connected to a dedicated network and a User-Interface on a computer, which allows these luminaires to be remotely managed.

Key benefits:



Constant Light Output (CLO)

Additional energy savings (over 20%) by using the Constant Light Output (CLO) and Virtual Light Output (VLO) functionality



Dimming schedules

Reducing the amount of light when not required, thereby reducing light glow as well as get further energy savings



Pro-active maintenance

The system reports errors and failures as they occur, helping to repair/ restore the luminaires pro-actively



Smart City devices

Connect additional Smart City devices including Air-quality monitors, Noise sensors, Motion sensors etc



For more information on smart controls contact: info@scs-schreder.com

GENERAL INFORMATION

Recommended installation height	4m to 7.5m 13' to 25'
Driver included	Yes
RCM Mark	Yes
ROHS compliant	Yes
Testing standard	EMC compliant: AS/NZS CISPR15 Luminaires Performance: AS/NZS 60598.1 & AS/NZS 60598.2.3 Lighting for Roads and Public Spaces: SA/SNZ TS 1158.6

HOUSING AND FINISH

Housing	Pressure die cast aluminium body
Optic	Polycarbonate
Protector	Acrylic
Housing finish	Grey polyester powdercoat finish as standard (other colours available on request)
Standard colour(s)	RAL 9006 Any other RAL color on request
Tightness level	IP66 - Optic & Gear Chamber IP24 Connection Chamber
Impact resistance	IK06 for standard visor IK07 for aeroscreen visor
Vibration test	Compliant with AS1158.6:2015, AS60068.2.6:2003
Access for maintenance	Tool-less

PERFORMANCE

Lumen efficacy	125lm/s/w
----------------	-----------

ELECTRICAL INFORMATION

Electrical class	Class 1
Nominal voltage	220V-240V – 50Hz/60Hz
Power factor (at full load)	> 0.9
System wattage	13.7W-24W
Surge protection options (kV)	10kV
Electromagnetic compatibility (EMC)	AS/NZS CISPR15
Control protocol(s)	DALI or 1-10V
Socket(s)	NEMA 7 pin or Zhaga BOOK 18 4 pin receptacle with 24V control
Sensor(s)	Devices & sensors for smart city applications

OPTICAL INFORMATION

LED colour temperature	2200K, 3000K, 4000K,
Colour rendering index (CRI)	> 70
Upward Light Output Ratio (ULOR)	0%

OPERATING CONDITIONS

Temperature range from operation (Ta)	-10°C up to +40°C
---------------------------------------	-------------------

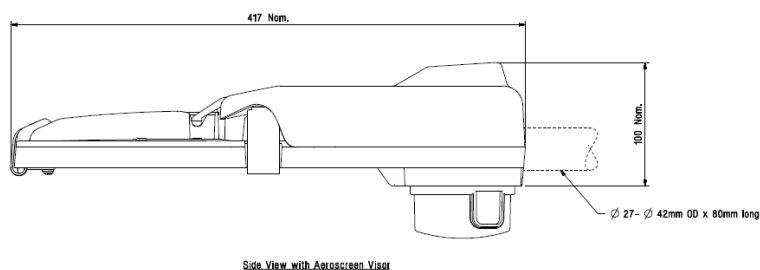
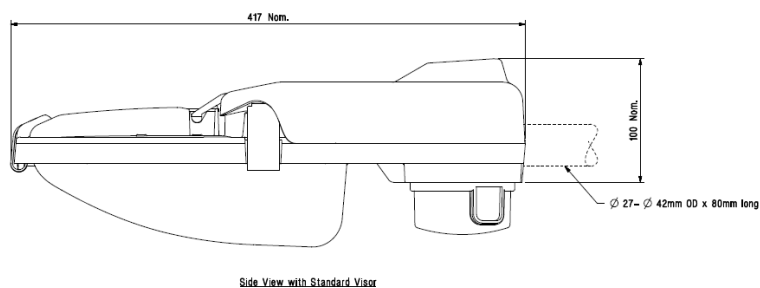
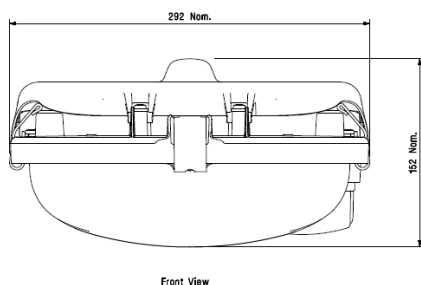
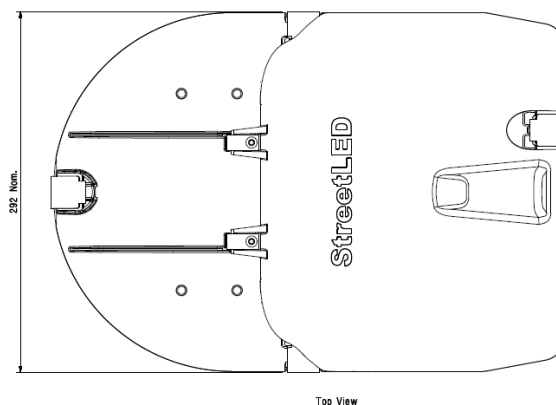
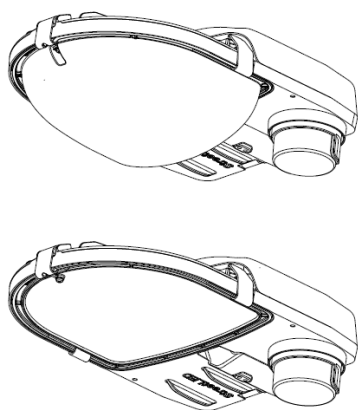
(*) Depending on the configuration of the luminaire. For more details, contact us.

LIFETIME OF THE LEDS @ TQ 40°C

All configurations	88,000h - L95
--------------------	---------------

DIMENSIONS AND MOUNTING

L x W x H (mm)	417 x 292 x 152
Weight (kg)	4.5
Mounting possibilities	27-34mm O.D. spigot entry





Product Code	Name	Beam Dist.	System Power (W)
JLC99Z05L17	STREETLED III 17W 4K PESN7	TYPE 3	17
JLC99Z15L17	STREETLED III 17W 4K PESN7 CO	TYPE 3	17

ACCESSORIES

JLC00010	5° Tilt Spigot Adjuster
JLB00000	SCO Spare Visor
JLB00002	CO Spare Visor
JLB00003	Rear Shield
JLB00004	Pathway Visior
JLB00005	360° Glare Shield
JLC00006	Louvres
JLB00000PC	Polycarbonate IK10 SCO Visor
JLB00002PC	Polycarbonate IK10 Aeroscreen Visor
JLB00007	Wire Guard

Appendix I: Greenhill Lighting Designers for Carrickalinga Streetlight Upgrade

Project No: P23.3457

11 December 2023

Carrickalinga Rate Payers Association (CRA)

Dear Amy,

RE: Carrickalinga Street Light upgrade

INTRODUCTION

GREENHILL is pleased to present our submission for the supply of lighting services for the assessment of Carrickalinga street light upgrade for ADSA compliance.

We understand the objectives of the project site outlined in the respective Consultant Brief. We understand the project objective is to produce a street light design, on existing poles, that ensures compliance with both Australian Standards and Dark Sky compliance standards. This will also include ensuring the lighting meets the latest AS1158 standards and no worse than current lighting. GREENHILL will also produce a set of drawings that can be priced for construction by SA Power Networks Road Lighting team.

Being a multi-disciplinary consultancy firm, we have extensive experience in detailed electrical & lighting design and documentation for local government and developer clients. We are very committed to establishing a long-term relationship that respects the client, the community and the environment. We will provide a collaborative client-orientated design service to the Council through open teamwork and communication.

Our proposal offers the following key advantages:

Personnel / Resources – GREENHILL employs over 40 skilled and experienced civil, road & transport and electrical & lighting engineers and technical officers, landscape architects and urban designers to assist with planning, design development and review, tender and construction. All staff are based in Adelaide, South Australia.

Experienced Team – We propose Greg Ocampo, Electrical Engineer, as the Team Lead for this project. Greg has over 13 years' including overseas and local, as an Electrical Engineer working on civil infrastructure and electrical services. He has been responsible for the preparation of concept, preliminary, and detailed design up to tender and construction stage in various projects. Greg is experienced in undertaking lighting designs for arterial and local roads, public realm and architectural projects. Greg has in-depth understanding of AS/NZS 3000, AS/NZS 3008, AS/NZS2293, AS/NZS 1158, AS/NZS 1680, NCC-BCA, SAPN and DIT standards. Greg has also extensive experience in Safety in Design and Value Engineering and is a member of IE Aust and the Illuminating Engineering Society.

Greg will be working alongside Andrew Haines, Manager – Electrical & Lighting and Greg Ocampo, Electrical Engineer.

Andrew has been working as a Project Manager and leader with more than 25 years' experience in Program and Project Management, Contract Management, Risk Management and Safety in Design.

Utilizing a strong base of technical knowledge, Andrew is highly regarded for his ability to build and maintain strong relationships with key stakeholders, both internal and external to the business. He has worked closely with Local, State and Federal Governments, major customers and key internal stakeholders and departments to improve relationships by building trust between parties, understanding all party's needs, concerns and non-negotiables and always looking to move forward towards a win-win outcome while ensuring that a best for business outcome is considered. Andrew also has extensive experience in developing and using ISO9001, ISO45001 and ISO14001 accredited Management Systems, Quality Assurance and Business Improvement processes, Safety in Design (SID), Value Engineering and constructability assessments.

PROJECT DELIVERABLES

The following section outlines our understanding and appreciation of the scope of works and deliverables for the project in accordance with the design brief of the RFQ:

- Public Lighting Category as per AS/NZS 1158.3.1: Current category to be confirmed by Council for existing lighting.
- Two stages of works are anticipated:
 - Preliminary Assessment: Lighting design for the 36 Carrickalinga street lights (as per the included spreadsheet;
 - Selection / confirmation of a suitable luminaire (ADSA and SAPN / AEMO unmetered loads table);
 - Lighting assessment in AGI32 for current luminaires;
 - Lighting assessment in AGI32 for proposed luminaire;
 - Review compliance requirements with Isolux diagrams to be submitted for Council review with both Australian Standards and 2018 Dark Sky Guidelines.
Note: Any additional poles / luminaires required to meet Council minimum lighting standards to be completed as a variation; and
 - Identify any non-complaint areas and provide recommendations to CRA and Yankalilla Council.
 - Detailed Design:
 - Prepare detailed design documentation in accordance with AS1158.3.1 for proposed fitting replacements only;
Note: Any additional poles / luminaires required to meet Council minimum lighting standards to AS1158.3.1 to be completed as a variation;
 - Drawings to be submitted to SAPN Road Lighting group for review / bracket checks;
 - Seek a quote, on behalf of CRA and Council, from SAPN Road Lighting group for the upgrade of the luminaires to a Dark Sky approved fitting.
note: fees associated with preparation of the SAPN quotation will be subject to a separate fee payable directly to SAPN by CRA / Council

GREENHILL is familiar with current Australian Standards, SAPN Technical Standards and Drawings, Austroads Guide to Road Design, having extensive experience in the successful delivery of numerous projects for the Department for various Local Government Authorities, the Department for Infrastructure and Transport (DIT) and private developers.

PROJECT METHODOLOGY

GREENHILL has reviewed the Request for Quotation and understands the specifications and requirements of the assessment and design of the public lighting upgrade as per the design brief.

Our methodology elaborates on our proposed approach to undertaking lighting design and documentation and provides additional evidence of our appreciation of the requirements of these projects.

The methodology proposed for the detailed assessment and documentation will be outlined under the following activities in accordance with the Scope of Work:

- We do not believe a site visit is justified on this occasion. We propose an online kick off meeting with key personnel to confirm luminaire selections, current lighting categories, capture any previous work, outstanding lighting issues;
- Confirm construction priority with Council to finalise project delivery timeline;
- Confirm lighting category with Council;
- Review existing Council civil and lighting plan for the Carrickalinga streets;
Note: GREENHILL assumes that Council can provide existing AutoCAD drawings, survey plans and alignments of the development;
- Lighting assessment / design to achieve ADSA compliance and ensure that current lighting category is no worse;
- CRA / Yankalilla Council to approve preferred concept scenario (Preliminary Assessment) before proceeding to Detailed Design;
- Prepare AGI32 Lighting Simulations and Isolux plots for the current and selected luminaire fitting;
- Confirm Voltage drop calculations for Electrical & Lighting circuits are still suitable;
- Liaison with SAPN to seek pricing on behalf of the CRA;
Note: Fees associated with preparation of the SAPN quotation will be subject to a separate fee payable directly to SAPN by CRA / Council;
- Regular communication with CRA / Council's Project Manager; and
- Preparation of "For Construction" design and documentation to be submitted for Council Review and submission to SAPN for pricing.

Experience – GREENHILL has extensive experience working for both private developers, Local and State Government on local road and streetscape projects. A small sample of recent projects are provided below but not limited to:

- Reserve pathway lighting, St Andrew's development, for City of Playford to ADSA compliance;
- Stafford Street, Stafford Lane and O' Halloran Street, Royal Ave, Gunson Street, Gray Street, Beaumon Street South Projects, City of Adelaide (in progress);
- North West Precinct Pathway Lighting and BBQ's, City of Port Adelaide Enfield;
- LJ Lewis & Edward Smith Reserves – Detailed Design, City of Port Adelaide Enfield;
- St. Andrews Reserve Pathway Lighting Design, City of Playford;
- City Wide Trails Pathway Lighting Design, City of Salisbury;
- Jetty Street, Grange – Lighting Design, City of Charles Sturt; and
- Rymill Park, Adelaide – Lighting Design, City of Adelaide.

QUALITY SYSTEMS, LICENCES AND ACCREDITATIONS

GREENHILL is committed to the provision of engineering services in the context of a quality management system, namely ISO 9001:2015 “Quality Management Systems” as the basis of our formal documented quality system. This System, certified independently by SAI Global, applies to all services provided by the company and is a key management tool which we use to ensure the quality of the services provided.

GREENHILL are accredited with NBN as nbn™ trained, Pathway Designer, Pit and Pipe Designer.



The GREENHILL approach to our business is client centric, and the company is focused on creating a positive experience for our clients.

Our company holds memberships with



- Urban Development Institute of Australia (UDIA)
- Institute of Public Works Engineering Australia (IPWEA)
- Stormwater Industry Association
- Australian Institute of Traffic Planning and Management (AITMP)
- Civil Contractors Federation South Australia (CCF SA).



Our talented staff are encouraged to actively participate within the industry



- Monish Bhindi (Director) is the Treasurer and Immediate Past President of the UDIA - SA Division
- Cindy Oliver (Principal Engineer) is on the Greenfield committee of the UDIA SA Division. She was also the former secretary of Stormwater Industry Association



Additional information



- Monish Bhindi, Cindy Oliver and Usman Khan all hold memberships with Engineers Australia.
- Monish and Cindy are Chartered Professional Engineers (CPEng) and they also hold registration with National Engineering Register (NER).
- Amy Prince, Paul Wong, Laura Johnson and Simon Gallucci are AILA Registered Landscape Architect (RLA) members.
- Greg Ocampo holds an Associate membership of IES: The Lighting Society.



PROJECT TIMELINE

Please find the proposed project timeline with key milestones below:

Stage	Start Date	Duration
Lighting Assessment	On award	1-2 weeks
CRA / Council Review (Hold Point)		2 weeks
Detailed Design and Documentation	Council confirmation to proceed	1-2 weeks
Submission to SAPN Road Lighting for quote		TBC
Final Amendments + IFC drawings	Council confirmation to proceed	1 week

Total design program is anticipated to be approximately 7 weeks including Council's review hold points (excluding SAPN Road Lighting team).

GREENHILL will be happy to discuss the detailed program further and discuss opportunities to accelerate this program on award.

FEES

We propose a lump sum fee of **\$5,500.00 (excluding GST)** for the above scope of works.

This includes the following:

- Lighting assessment and design.
- Liaison with CRA / Council and authorities.

Should the scope of our services change, we propose to undertake those changes at our standard hourly rates. Our standard hourly rates (excluding GST) are as follows:

- Manager, Electrical & Lighting \$225/hr
- Electrical Engineer \$155/hr
- Electrical Drafter \$110/hr

QUALIFICATIONS AND ASSUMPTIONS

Our fee has been prepared based on the above scope of works, except, where clarified in the qualifications and assumptions below:

No. Assumptions	
1.	CRA / Council to confirm a preferred luminaire selected for this project.
2.	Council to provide civil design, alignments, lot layouts and survey plans in AutoCAD format for the existing pole locations.
3.	Allowance has been made to consult key CRA / Council stakeholders and advisors during the design stage; Additional liaison required will be liaised with council and carried out on standard hourly rates.
4.	Detailed design to be based on one (1) lighting selection only.
5.	Detailed costs to be prepared by SAPN Road Lighting Team and will be subject to a separate fee payable direct to SAPN by CRA / Council.
6.	Allowance to liaise with SAPN Road Lighting Team regarding ADSA approved luminaires.
7.	All electrical and public lighting design will be undertaken to AS3000, SAPN, AS1158 Standards and ADSA Guidelines.
8.	This Contract is in line with our standard Consultancy Agreement.
9.	Existing light poles are suitable to have the new ADSA approved fitting installed.

No. Exclusions	
1.	Alternation/modifications to SAPN electrical infrastructure (poles, additional lights beyond 38, service points etc.) and associated non-contestable designs.
2.	Topographical and underground services surveys.
3.	Any telecommunications and / or other services are excluded. These third-party relocation designs are normally managed by the utility authorities; however, we will work closely with these authorities to achieve a successful outcome.
4.	No allowance for service authorities' charges and fees for services relocation designs.
5.	No allowance for preparation of an obtrusive compliance report as per AS4282 and spacing calculations as per AS1158 and rectify issues associated with obtrusive lighting and lighting spacing requirements. Note: This can be carried out as a separate engagement and/or standard hourly rates basis.

No.	Exclusions
6.	No allowance for council meetings. This can be carried out as a separate engagement and/or standard hourly rates basis.
7.	Attending communication consultation and public events.
8.	Services locating, depthing and survey of located services. We have assumed that the existing light poles can be retrofitted with a new luminaire.
9.	Arborist services, heritage, cultural or historical significance investigations.
10.	Critical Root Zone (CRZ) assessments and investigations.
11.	Building services engineering designs.
12.	Review of multiple public lighting selections.
13.	Lighting pole footing designs and related structural engineering assessments/investigations.
14	“Tender” and “Construction” support activities. Note: This can be carried out as a separate engagement and/or standard hourly rates basis.
15	A site meeting has been excluded from the fees as it was deemed not required. Note: This can be carried out as a separate engagement and/or standard hourly rates basis.

We look forward to your consideration of this proposal and the opportunity to work with you in the near future. Should you have any queries regarding the above please do not hesitate to contact me on 0428 477 646 or email ahaines@greenhillaustralia.com.au.

Yours sincerely,

For GREENHILL

Andrew Haines

Manager – Electrical & Lighting Team

A handwritten signature in black ink, appearing to read 'A Haines', written in a cursive style.

Attachments:

27444 GREENHILL Consultancy Agreement.pdf

Appendix 4.3 The survey instrument for a dark sky community

Carrickalinga Dark Sky Community (DSC) Survey

Surveyor: _____ Date Time Location: _____

There is interest within the Carrickalinga community in becoming the first International Dark Sky Community in Australia. International Dark Sky Communities are cities or towns that undertake efforts to enhance the appreciation and value of dark skies. Australia has one International Dark Sky reserve (River Murray) and an International Dark Sky Park (Warrumbungle National Park); however, currently there are no International Dark Sky Communities in Australia. We are interested in your thoughts, on the possibility of Carrickalinga becoming a Dark Sky Community (DSC).

For each of the following statements, please indicate your level of agreement, using the following scale: (1= strongly disagree, 2= disagree; 3=neutral; 4=agree; and 5=strongly agree).

A Carrickalinga DSC would save money on energy, hardware, and maintenance related to street and other night lighting.

SD		N		SA
1	2	3	4	5

A Carrickalinga DSC would improve human health (e.g. reduce sleep disorders)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would enhance public safety (e.g. reduces night vision capacity, reduces glare)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would provide ecological benefits (e.g maintaining normal predator-prey relationships)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would provide wildlife benefits (e.g reduces disorientation and feeding problems of some species)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote interest in cultural history (eg. Navigation and Aboriginal stories)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote interest in learning about the night sky

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote off-season astro-tourism (e.g. ecotourism, astrophotography)

1	2	3	4	5
---	---	---	---	---

The following questions relate to your personal experience with Carrickalinga and overall Starry Nights

Please rate your level of agreement using the same scale where 1 is “strongly disagree” and 5 is “strongly agree.”

On a typical trip to Carrickalinga, I consciously look at the night sky. .

SD		N		SA	
1	2	3	4	5	NA

I have no interest in attending a night sky viewing /astronomy event on the Carrickalinga beach.

1	2	3	4	5	NA
---	---	---	---	---	----

Carrickalinga has a special ‘sense of place’ for me.

1	2	3	4	5	NA
---	---	---	---	---	----

I have a sense of awe when I experience natural night skies.

1	2	3	4	5	NA
---	---	---	---	---	----

I feel the Carrickalinga night sky is exceptional compared to other places.

1	2	3	4	5	NA
---	---	---	---	---	----

The night skies are irrelevant to my personal quality of life.

1	2	3	4	5	NA
---	---	---	---	---	----

What is your relationship to Carrickalinga? Check all that apply

Carrickalinga Resident

☐
☐
☐

Visitor (returning)

☐
☐
☐

Carrickalinga Property Owner

Yankalilla Council Business Owner

First time visitor

Astronomy Enthusiast

Demographic Information

Please circle the value that most closely represents you:

Age Groups 18-----25-----30-----35-----40-----45-----50-----55-----60-----65-----70+

Annual Household Income before Tax

25,000-----50,000 -----100,000-----150,000 -----200,000+

Sex Female Male Prefer not to identify

Education < Secondary School Secondary School TAFE qualification Some Uni
Bachelors Master PhD

What would you like to know more about (if any 😊)?

Night sky viewing/astronomy

☐
☐
☐

Light pollution effects

☐
☐
☐

Viewing wildlife at night

Ways to reduce light pollution

Aboriginal Cosmos

Weather for Night sky viewing

Would you like to be sent a copy of the survey results?

☐

YES. PLEASE SEND ME A SUMMARY OF THE SURVEY RESULTS

My email address is.....

(If you prefer an email response)

Are you happy to be involved in other surveys about dark skies ? *Please tick one response.*

☐ Yes

☐ No

THANK YOU FOR YOUR HELP!

Privacy Note:

We are committed to keeping the information you provide in this survey strictly confidential.

The University of South Australia (UniSA) authorizes the collection of this information. This information will be used in Council discussions pertaining to a DSC nomination. Permanent data will be anonymous and will be stored in a locked office at UniSA for a period of five years, after which it will be destroyed. Completion of this survey is voluntary. The survey has been approved by the UniSA Human Ethics Committee. If you have any ethical concerns, please contact humanethics@unisa.edu.au, Executive Officer of the Human Research Ethics Committee at the University of South Australia, SA, on 203858

Carrickalinga Dark Sky Community (CDSC) Survey

Surveyor: ACC-Shawley Date Time Location: P-Bldg

There is interest within the Carrickalinga community in becoming the first International Dark Sky Community in Australia. International Dark Sky Communities are cities or towns that undertake efforts to enhance the appreciation and value of dark skies. Australia has one International Dark Sky reserve (River Murray) and an International Dark Sky Park (Warrumbungle National Park); however, currently there are no International Dark Sky Communities in Australia. We are interested in your thoughts, on the possibility of Carrickalinga becoming a Dark Sky Community (DSC).

For each of the following statements, please indicate your level of agreement, using the following scale: (1= strongly disagree, 2= disagree; 3=neutral; 4=agree; and 5=strongly agree).

A Carrickalinga DSC would save money on energy, hardware, and maintenance related to street and other night lighting.

SD			N		SA
1	2	3	4	5	

A Carrickalinga DSC would improve human health (e.g. reduce sleep disorders)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would enhance public safety (e.g. reduces night vision capacity, reduces glare)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would provide ecological benefits (e.g maintaining normal predator-prey relationships)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would provide wildlife benefits (e.g reduces disorientation and feeding problems of some species)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote interest in cultural history (eg. Navigation and Aboriginal stories)

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote interest in learning about the night sky

1	2	3	4	5
---	---	---	---	---

A Carrickalinga DSC would promote off-season astro-tourism (e.g. ecotourism, astrophotography)

1	2	3	4	5
---	---	---	---	---

The following questions relate to your personal experience with Carrickalinga and overall Starry Nights

Please rate your level of agreement using the same scale where 1 is "strongly disagree" and 5 is "strongly agree".

On a typical trip to Carrickalinga, I consciously look at the night sky.

1	2	3	4	5
---	---	---	---	---

I have no interest in attending a night sky viewing /astronomy event on the Carrickalinga beach.

1	2	3	4	5
---	---	---	---	---

Carrickalinga has a special 'sense of place' for me.

1	2	3	4	5
---	---	---	---	---

I have a sense of awe when I experience natural night skies.

1	2	3	4	5
---	---	---	---	---

I feel the Carrickalinga night sky is exceptional compared to other places.

1	2	3	4	5
---	---	---	---	---

The night skies are irrelevant to my personal quality of life.

1	2	3	4	5
---	---	---	---	---

What is your relationship to Carrickalinga? Check all that apply

Carrickalinga Resident

☐
☐
☒

Visitor (returning)

Carrickalinga Property Owner

Yankalilla Council Business Owner

First time visitor

Astronomy Enthusiast

☐
☐
☐

Demographic Information

Please circle the value that most closely represents you:

Age Groups 18-----25-----30-----35-----40-----45-----50-----55-----60-----65-----70+

Annual household Income before Tax

25,000-----50,000-----100,000-----150,000-----200,000+

Sex Female Male Prefer not to identify:

Education < Secondary School Secondary School

Bachelors Master PhD

TAFE qualification

Some Uni

What would you like to know more about (if any 😊)?

Night sky viewing/astronomy

Viewing wildlife at night

Aboriginal Cosmos

☒
☒
☒

Light pollution effects

Ways to reduce light pollution

Ways to reduce light pollution

☒
☒
☒

Appendix 4.4 Frequently Asked Questions and Answers

FAQ - Carrickalinga Dark Sky Community

Dr Sharolyn Anderson and Dr Sheryn Pitman

September 2022

What is a Dark Sky?

A Dark Sky is a natural night sky unaffected by light pollution.

What is light pollution?

Light pollution, or artificial light at night, is the presence of unwanted, inappropriate or excessive artificial lighting.

It disrupts the natural patterns of wildlife, contributes to the increase in carbon dioxide (CO₂) in the atmosphere, disrupts human sleep, and obscures the stars in the night sky.

Artificial light is light ranging in wavelength from the ultra violet to the near-infrared that is caused, directed or used by humans for any purpose.

Components of light pollution include:

- Glare – excessive brightness that causes visual discomfort
- Sky glow – brightening of the night sky over inhabited areas
- Light trespass – light falling where it is not intended or needed
- Clutter – bright, confusing and excessive groupings of light sources

Light pollution is a product of modern civilization. Sources of light pollution include buildings (exterior and interior lighting), advertising, commercial properties, offices, factories, streetlights and illuminated sporting venues.

What are the problems with light pollution?

Light pollution is one of the most significant changes that humans have made to the natural environment and can have serious consequences for humans, wildlife, ecosystems and our climate. It is a rapidly growing problem around the world.

Human health: Excess light at night lowers melatonin production, which has been shown to result in sleep deprivation, fatigue, headaches, stress, anxiety, and other health problems. Depression, obesity and breast cancer have also been linked to excessive night-time lighting.

Wildlife: Life on Earth relies on the predictable rhythms of day and night. Wildlife and ecosystems have evolved with day-night cycles and light pollution disrupts the natural behaviour patterns of wildlife including predator-prey relationships, foraging and feeding, mating and reproduction, wayfinding and migration. Well-known examples where light pollution has had detrimental effects include Bogong moths (insects), sea turtles and migratory birds.

Energy: Use of artificial light at night contributes to the increase in carbon dioxide (CO₂) in the atmosphere through energy use. Because we produce so much excess light, much of this energy use is unnecessary.

Visibility of the night sky: Light pollution obscures the visibility of stars in the night sky. Studies show that over 1/3 of people in the world cannot see the Milky Way and that its visibility is continually decreasing.

Experiencing the night sky provides perspective, inspiration and helps us to reflect on our place in the universe. The history of scientific discovery and even human curiosity itself is indebted to the natural night sky.

Visible access to night skies has always been, and remains, critical for navigation and astronomy.

What is the Dark Skies movement?

It is an international commitment to protect the night skies for present and future generations. For over two decades, the International Dark-Sky Association has managed the award-winning International Dark Sky Places Program (IDSP).

The movement encourages communities all over the world to upgrade to more efficient and appropriate lighting, to reduce unnecessary lighting, and to value the night skies for their benefits and beauty.

Australia has amazing night skies, such as those of Carrickalinga, and yet these too are being continually degraded by surrounding light pollution. Becoming a Dark Sky Community will help protect the community and environment from local light pollution and provide inspiration for surrounding areas to protect our spectacular night sky.

What is smart lighting?

Lighting is 'smart' when appropriate for the task, and refers to where, when and the amount of light produced. This is better termed 'smart lighting design' where the need, the timing and the minimum requirements for light are assessed.

Smart lighting means that we:

- Use targeted lighting - light only when and where we need
- Use shielded lights and direct them downward, avoiding light trespass
- Use energy efficient bulbs that are no brighter than necessary
- Use warm white or amber-coloured bulbs
- Use controls such as motion sensors and dimmers

The term 'smart lighting' is also used to refer to the ability to control lighting options through the internet, an integrated system that involves light sources, luminaries, sensors and control units, connectivity and analytics.

Night sky friendly lighting is a win-win-win option. It provides health and safety benefits, assists our wildlife, and saves money.

Is smart lighting safe?

It is an urban myth that *more* light is safer. In truth, the research finds that *well-designed* lighting is safer.

Visibility should always be the goal. Glare from bright, unshielded lights actually decreases safety because it shines into our eyes and constricts our pupils.

Carefully targeted and uniform lighting are critical element of night-time safety. Bright and glary lights are shown to detract from safety.

Safety is of concern to all communities and is one of the benefits of smart lighting. By carrying out lighting inventories and assessments, communities can identify and retrofit inappropriate lighting (especially glare) and make places safer and more secure.

'Dark sky' does not mean 'dark ground'. Smart lighting means you can have a dark sky without losing light on the ground.

Why become a Dark Sky Community?

There are human health, ecological health and economic benefits in protecting the natural night sky.

The human health benefits are many and range from better sleep to physical and mental well-being. Plants and animals, and indeed whole ecosystems, have evolved with the natural day/night cycles and so keeping this as natural as possible is of great benefit for wildlife, and essential for the survival of many species. Economic benefits are also very clear, with energy savings translating directly into monetary savings. This also helps with mitigation of climate change by reducing energy production emissions into the atmosphere.

Investment in the future of dark skies is valuable for many reasons.

An IDA International Dark Sky Community is a town, city, municipality or other legally organized community that has shown exceptional dedication to the preservation of the night sky through the implementation and enforcement of a quality outdoor lighting ordinance, dark sky education and citizen support of dark skies. Dark Sky Communities excel in their efforts to promote responsible lighting and dark sky stewardship, and set good examples for surrounding communities.

<https://www.darksky.org/our-work/conservation/idsp/communities/>

Why Carrickalinga?

The “Made by Nature” Fleurieu Peninsula community of Carrickalinga has only 38 streetlights. The upgrade of these lights can be achieved for little cost and effort, and Carrickalinga could then become the First Dark Sky Community in Australia. With less than forty such ‘communities’ in the world at this stage, this would be a great accomplishment indeed.

Not only do we reduce light pollution, improve human and environmental health, and save both money and energy while reducing greenhouse gas emissions, residents and visitors alike can enjoy the night skies into the future. Stargazing brings joy and wonder to all of us in different ways and the starry skies of the Fleurieu Peninsula are precious.

What can I do at home to reduce light pollution and contribute to the Dark Skies movement?

There is much we can all do at home and at work.

To begin with, use dark sky friendly lighting. Assess the outdoor lighting around your home or business to ensure it is smart/well-designed, remembering that well-designed outdoor lighting has benefits such as:

- Lower power bills and greenhouse gas emissions through efficient energy use
- Improves security by avoiding glare
- No light spillage or trespass to annoy neighbours, motorists or pedestrians
- Reduced disruption to wildlife feeding and breeding, including to nocturnal animals
- Preservation of the night sky

When you upgrade home or business lighting, use smart lighting.

Use outdoor lighting only when and where it is needed, make sure outdoor lights are properly shielded and directed down instead of up into the sky, and close window blinds, shade and curtains to keep light inside.

You may like to take part in the Globe at Night international citizen science campaign to raise public awareness of the impact of light pollution by inviting citizen-scientists to measure submit their night sky brightness observations. It's easy to get involved - all you need is computer or smart phone: <https://www.globeatnight.org>

For further information please visit:

<https://www.darksky.org/>

<https://education.nationalgeographic.org/resource/light-pollution>

<https://www.lrc.rpi.edu/programs/nlpip/lightinganswers/lightpollution/abstract.asp>

<https://www.jmu.edu/planetarium/light-pollution.shtml>

<https://www.lrc.rpi.edu/programs/nlpip/lightinganswers/lightpollution/glare.asp>

[National Light Pollution Guidelines for Wildlife \(agriculture.gov.au\)](#)

[Building and development factsheets | Clarence Valley Council \(nsw.gov.au\)](#)

[Lighting, Crime and Safety - International Dark-Sky Association \(darksky.org\)](#)

<https://www.darksky.org/wp-content/uploads/2014/09/Chicago-Alley-Lighting-Project.pdf>

Appendix 5.1 Pre- Post- Intervention Survey

Pre- Post- Survey for Intervention Study

Section 1:

Implied Consent

You are invited to join a research project on **Ecological Literacy and Light Pollution**. The purpose of this study is to assess baseline levels of knowledge of the ecological impacts of light pollution and how an individual's 'connectedness to nature' might be impacted by experiential and/or educational interventions. You were selected as a possible participant in this study because you are a student at the University of Denver. You may choose not to participate in the study for any reason without penalty. There are no expected risks to you as a result of participating in this study. Thanks for considering this request to participate.

If you have any questions about this project or your participation, please feel free to ask questions now or contact Paul Sutton at Paul.Sutton@du.edu 303 871-2399 at any time.

The detailed consent form is found at this location - copy and paste to your browser if you want to read the document

<https://urizenapw02->

[vlp.du.edu/~paul.sutton/AAA_Sutton_WebPage/interventionDocs/Exempt_Consent_PCS_v3.pdf](https://urizenapw02-vlp.du.edu/~paul.sutton/AAA_Sutton_WebPage/interventionDocs/Exempt_Consent_PCS_v3.pdf) but you can skip this and continue to the survey, and we will assume you are providing your consent to be part of this study.

Section 2:

Student Identification

We use your ID to match your first and second responses. All identifying information is deleted once the data is assembled for analysis.

First Name

Last Name

Student ID

Section 3:

Connectedness to Nature Scale

The Connectedness to Nature Scale (CNS) measures to what degree people feel part of nature (Mayer & McPherson Frantz, 2004).

For each of the following statements, use the scale to indicate your level of agreement ranging from strongly disagree to strongly agree. Please be as honest as you can. There are no right or wrong answers.

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
I often feel a sense of oneness with the natural world around me.					
I think of the natural world as a community to which I belong.					
I recognize and appreciate the intelligence of other living organisms.					
I often feel disconnected from nature.					
When I think of my life, I imagine myself to be part of a larger cyclical process of living.					

For each of the following statements, use the scale to indicate your level of agreement ranging from strongly disagree to strongly agree. Please be as honest as you can. There are no right or wrong answers.

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
I often feel a kinship with animals and plants.					
I feel as though I belong to the Earth as equally as it belongs to me.					
I have a deep understanding of how my actions affect the natural world.					
I often feel part of the web of life					
I feel that all inhabitants of Earth, human, and					

nonhuman, share a common "life force."					
--	--	--	--	--	--

For each of the following statements, use the scale to indicate your level of agreement ranging from strongly disagree to strongly agree. Please be as honest as you can. There are no right or wrong answers.

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
Like a tree can be part of a forest, I feel embedded within the broader natural world.					
When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.					
I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.					
My personal welfare is independent of the welfare of the natural world.					

Section 6:

Light Pollution Ecological Literacy

This survey is an attempt to gauge your general knowledge of the topic of light pollution. Please answer to the best of your ability *without looking up any of the answers*.

1. Light Pollution is best describe as:
 - a. The light produced when the moon and stars shine on a clear night
 - b. The excessive or inappropriate use of outdoor artificial light
 - c. City lights that have adverse health effects on people
 - d. Light that is produced by fossil fuel energy
 - e. Light that disrupts ecosystems

f. Don't know

2. Many species are dependent on natural cycles called circadian rhythms, which are regulated by light and dark. If humans are exposed to light while sleeping, there can be several consequences. Which of the following is **not** considered to be a likely problem caused by light exposure while sleeping?
 - a. suppression of melatonin production
 - b. increased risk of certain cancers
 - c. increased stress and anxiety
 - d. increased fatigue at work
 - e. decreased ability to see in the dark
 - f. don't know
3. Light pollution affects migratory birds in a number of ways. Which following statement is true?
 - a. Light pollution helps keeps birds on course on long migrations
 - b. Light pollution provides a navigation aid on dark cloudy nights
 - c. Light pollution prevents birds from colliding with buildings and towers
 - d. Light pollution extends the migratory season for many species
 - e. Light pollution can cause birds to wander off-course during migration
 - f. Don't know
4. Which of the following is **not** a source of ecological light pollution?
 - a. Lighted building and towers
 - b. Streetlights
 - c. Fishing boats
 - d. The full moon
 - e. Lights on undersea research vessels
 - f. Don't know
5. Insect populations are declining world-wide. Which of the following statements about artificial light is **true**?
 - a. artificial light can help many insect species to find food
 - b. artificial light can assist in pollination of plants
 - c. artificial light can create a fatal attraction for insects
 - d. artificial light can help insects to avoid predators
 - e. artificial light can make it easier for insects to find mates
 - f. don't know
6. Which color of artificial lights has the greatest impact on wildlife?
 - a. Red
 - b. Yellow
 - c. Green
 - d. Violet
 - e. Blue
 - f. Don't know

7. Which of the following statements about artificial light is **true**?
- a. Artificial light helps nocturnal animals to see in the dark
 - b. Artificial light assists predators that use light to hunt their prey
 - c. Artificial light helps prey species to avoid predators
 - d. Artificial light stimulates night time croaking which is part of the breeding ritual of frogs
 - e. Artificial light improves the reproduction cycles of many species by providing greater visibility
8. Light pollution has impacts on coastal and marine ecosystems. Which of the following is **not** an impact of light pollution in these environments?
- a. seabeds near cities are brighter at night in cloudier conditions
 - b. disorientation of the navigation abilities of sea turtles
 - c. increased bird strikes on artificially lit vessels at sea
 - d. overcrowding of dark refuges by smaller species to avoid predators
 - e. interference with the complex light displays used by many species to confuse predators
9. Globally, which of the following is the **most** significant form of light pollution?
- a. Illuminated sporting venues
 - b. Streetlights
 - c. Bush- or wild- fires
 - d. Stars
 - e. Aircraft
10. Light pollution can be most effectively reduced by:
- a. Only using solar-powered lighting
 - b. Changing the color and temperature of streetlights
 - c. Keeping lights targeted and fit for purpose
 - d. Turning off all lights for at least an hour each night
 - e. Protecting sensitive areas from skyglow and stray light

11.

Appendix 5.2 Ecoliteracy Intervention Form

Ecological Literacy

The following task will take approximately 20 minutes. Please watch the videos and respond to each video with something you learned and something you already knew before watching the videos.

Thus, Answer A) What you learned and B) What you knew.

Please note that due to the limitation of the delivery method (ie. MS Form) there is only one box to answer both A) What you learned and B) What you knew.

Please think about answering

A) One thing I learned from this video that I didn't know previously was...

B) One thing that I was already aware of that was reinforced in this video was...

Section 1:

Student Identification

We use your name and student ID to track changes in your responses between your first, interventions, and post surveys.

First Name

Last Name

Student ID

Section 2:

4

Losing the Dark <https://youtu.be/dd82jajtFlo> (6:25)

Please comment (in Enter your answer box) as A) and B)

A) One thing I learned from this video that I didn't know previously was...

B) One thing that I was already aware of that was reinforced in this video was...



Enter your answer

(<https://youtu.be/dd82jajtFlo>)

5

Light Pollution and Bats (2 complementary videos 2:34 min - below and 3:00 min
<https://youtu.be/XUjx8rswzn8> (3 min) copy and paste URI or click second link)



Enter your answer

(<https://youtu.be/4helqgmghU>)

6

Lights off for Bogong Moths (46 sec)

Please comment (in Enter your answer box) as A) and B)

A) One thing I learned from this video that I didn't know previously was...

B) One thing that I was already aware of that was reinforced in this video was...



Enter your answer

(https://youtu.be/1BKsa_4EumA)

7

The Ambush (2:11)

Please comment (in Enter your answer box) as A) and B)

A) One thing I learned from this video that I didn't know previously was...

B) One thing that I was already aware of that was reinforced in this video was...



Enter your answer

(https://youtu.be/1BKsa_4EumA)

8

Florida public service announcement on Hatching Turtle behaviors (0:26 sec)

Please comment (in Enter your answer box) as A) and B)

A) One thing I learned from this video that I didn't know previously was...

B) One thing that I was already aware of that was reinforced in this video was...



Enter your answer

(<https://youtu.be/3fKhpDmYO5I>)

9

Help Protect Wildlife (1:18)

Please comment (in Enter your answer box) as A) and B)

A) One thing I learned from this video that I didn't know previously was...

B) One thing that I was already aware of that was reinforced in this video was...



Enter your answer

(<https://youtu.be/ooLYWwA43SE>)

Please add any comments that you would like the researchers to know.

Appendix 5.3 Stargazing Intervention Form

Stargazing_Form

This exercise will require that you go outside three nights and view the skies. Please use any technology (ie. stargazing apps, etc) and/or the class handout of the night sky for this month (additional copies can be found online <https://www.skymaps.com/>)

For each of the evening stargazing - please enter the date and time of your night viewing followed by what you saw (which constellation, the space shuttle, etc). How did finding the celestial objects make you feel?

Section 1:

Student Identification

We use your ID to match your first and second responses. All identifying information is deleted once the data is assembled for analysis.

First Name

Last Name

Student ID

Section 2:

Observation Day One (first viewing)

Please input date (MM/DD/YYYY)

Enter time of observation (or approximate time)

What did you see? List the celestial objects (three) that you observed? (constellations, the space shuttle, etc).

Please describe in many details as you can how finding the celestial objects made you **feel**?

Section 3:

Observation Day One (second viewing)

Please input date (MM/DD/YYYY)

Enter time of observation (or approximate time)

What did you see? List the celestial objects (three) that you observed? (constellations, the space shuttle, etc).

Please describe in many details as you can how finding the celestial objects made you **feel**?

Section 4:

Observation Day One (third viewing)

Please input date (MM/DD/YYYY)

Enter time of observation (or approximate time)

What did you see? List the celestial objects (three) that you observed? (constellations, the space shuttle, etc).

Please describe in many details as you can how finding the celestial objects made you **feel**?

What is your level of agreement with the following statements:

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
Prior to this experience I regularly gazed at the stars as a form of relaxation and inspiration.					
Prior to this experience I regularly gazed at the stars and identified celestial objects					
I think stargazing will become a regular habit for me					

Please add any comments that you would like to share with the researcher:

Appendix 5.4 Table of the Stargazing results

ID	obs1	feel1	Comment
1	Orion's Belt	Good! My partner loves stars and we go on a walk every night so she can point out anything new. It's always fun.	
2	Just the Big Dipper, I live right on the Aurora Denver line so there is quite a bite of light pollution	The Big Dipper is always an easy, comforting constellation to find in the night sky. Unfortunately, I was stargazing from my back patio tonight and saw little else.	Stargazing would be a more regular hobby of mine if I lived in a more rural, less illuminated place. I tend to do most of my stargazing while camping or in remote places where I can see the night sky more fully.
3	Jupiters	I feel shocking and luck when I see the jupiters because I really thankful I can see the beautiful scene, and survive from	
4	Ursa Major, Polaris, ISS and good boy Leo	Watching the stars makes me realize how insignificant we are in the grand scheme of the universe. I try to find as many satellites and shooting stars as I can (I like to believe they are alien).	I looooooove stars :)
5	A few stars, light glare, Moon	Seeing the very little of the stars (as I did every night) was very saddening because being in a light polluted city, and knowing how the night should look just means we need to do better as a	
6	Mebсутa, Cancer, Taurus	Before looking at the app, they were beautiful and mesmerizing. Shining separately in their own ways. After looking through the app, they became more awe-inspiring, like the parts became whole. And with this, I would say it made me feel tiny in comparison since these celestial objects glow so brightly in the	Apologies for the third day and the second day, the first day was clear and many more celestial bodies were seen then listed.
7	Major constellations, like Orion's belt, the moon, was a waxing gibbus, and what I am guessing was a satellite, it was moving across the sky at a steady pase. Air planes also	Ever since I was little I have always looked for Orion's belt, for some reason it always brought me great comfort, seeing it brought back happy memories from my childhood.	next full moon is this Friday 3/18!
8	The Big Dipper, Orion's belt, Mars (possibly).	It makes me feel wonderous and excited to be able to look up and identify each constellation and planet.	
9	I saw airplanes, satellites, and stars. I saw a few clouds as well.	Finding these objects made me feel indifferent. Back home, I can see the night sky much clearer, and more planes fly by when I'm home too. Honestly, it was more disheartening than anything since I expected to see more stars.	

10	The moon	Finding the moon made me feel relaxed because it is very beautiful. It was pretty cloudy this night, but I was able to see the bright moon very clearly in the night sky.	This was a fun study to complete because I was able to take a small break from whatever I was doing and just focus on finding celestial objects in the sky. It gave me a chance to take a break from life and observe the beautiful night sky which was very relaxing.
11	In standing on the porch, and looking up at the night sky, I was able to see a cluster of two stars to the left of me when facing the mountains.	I found this activity to be very grounding, as it was a moment of stillness for me. To find a celestial object, I had to pause and take a moment. This reminded me of how there's so much going on around me, and how I don't pause enough to take in my surroundings. Especially at night, when I'm exhausted and ready	
12	The moon and stars	peaceful	
13	Constellations	At piece, it was quite and nice out	
14	I saw lots of constellations such as the big dipper and lots of stars clustered together, but also spread apart as well.	These celestial objects made me more curious about what extraterrestrial life might be out there and also happy and content that I got the opportunity to see these wonderful stars.	It was a very interesting experiment!
15	I observed the Orion constellation.	It made me feel good that I found it and was able to see it. I think Orion is a pretty easy constellation to find because of the belt.	I would like stargazing to be more of an activity I do but we'll see what happens.
16	moon, a shooting star, jet/plane	Seeing the moon and shooting star made me feel small as it reminded me of the grand size of the universe.	
17	I saw mostly planes and the sun was setting so i saw the sun and the moon both in the sky	I felt really peaceful and at one with nature. I was thinking about how i feel a part of something bigger than myself.	
18	I saw stars - I believe I made out a constellation or two. Although I do not no the names of the potential constellations (I have no background in this area), I really believe that I saw connections between various sets of starts. I'm not sure if this makes a difference, but I viewed the stars from Wash Park opposed to campus.	I enjoying looking at the sky as a piece of art. It was mindful, meditation esque. In middle school, I was a lot more connected to nature. So I felt a sense of nostalgia staring at the stars aimlessly.	I think stargazing is a perfect opportunity for me to be more mindful and meditate in the ways that I have been really needing it.
19	little dipper constellation	It made me feel really good being able to see the stars finally after not being able to see any stars while in the city for a long	
20	After looking for about 10 minutes I finally found the Big Dipper	Honestly, i was really disappointed that it took that long to find the Big Dipper since back at home, I can't find it in a matter of seconds.	It's hard to be a stargazer in denver because I rarely see the amount of stars that I would see back home in Nevada (reno)

21	the big dipper	I saw a few stars last night and a faint big dipper.	I enjoyed looking at the stars but sometimes they are hard to see.
22	the moon, Orion's Belt	they made me feel good. it made me feel at peace.	
23	An airplane	Seeing an airplane in the sky always amazes me as I find it crazy how we were able to invent "flying"	
24	Stars, moon	Looking at these objects make me feel small, but not in a bad way. It makes me realize how I am apart of such a huge system of working parts and my life is like a little speck just like a star is a little speck in the sky. I love looking at the stars because they are so beautiful but it also is calming and puts everything into	
25	I saw several stars, and a couple airplanes flying by. The clouds were covering the moon, but it wasn't very bright.	It felt peaceful, a little eerie though maybe	
26	It was super cloudy so I was not able to see much, but the moon was bright.	This still made me happy because I could see the contrast in the color of the clouds	
27	Polaris, Orion (faintly)	Polaris is very humbling, to think of this massive bright star that's millions of light years away shining down on me. It's amazing to think that people have used the North Star to navigate the Earth for years. Orion was hard to see, I find it funny how people find shapes in these stars. Just like a connect-the-dot drawing. The belt is easiest to spot, three stars in a line, that's what I could mostly see. There's so much history behind the stars and Earth and it blows my mind about how much is happening in space and how people have found meaning and	
28	I saw the big dipper and one plane in the sky flying over me	I felt intelligent to be able to spot it out among the other stars.	
29	Jupiter	It made me feel small and insignificant, even a planet the size of multiple earths looks like a regular star	
30	I was able to see the Big Dipper and take a picture of it as there was little light pollution in the area I was in. It contains eight stars a creates a ladle like shape.	Being able to see the Big Dipper so clearly made me feel at peace, and allowed me to realize that there are still places in the world where light pollution does not affect ones ability to see the stars as much. Although the Big Dipper is a common star formation, I was not able to spot it until about a year ago.	N/A
31	Stars, but I am not sure which constellations they were apart of, as well as a Waxing Crescent moon	I felt peaceful and relax while observing	

32	big dipper	They made me feel like I had something to believe in and hopeful for my future comings.	
33	The Little (or big?) Dipper, the lunar eclipse, Orion's belt	It made me feel connected with nature and at peace. I felt much more relaxed than being inside. I don't spend much time outside at night so it was a nice change. I felt connected to the Earth.	
34	Airplane	Made me curious and interested in the history behind the object, but still felt neutral and had no major feelings towards the object; I started to wonder about the backstory of the airplane, such as where it was coming from, where it was headed to, how many people were on the plane, and how long	
35	I saw Orion's Belt from a camping area north of Canon City	It made me feel really good and I was just happy to get out of the city and experience the quietness of the natural world.	
36	I believe I saw the superstar 119 tauri and Orion	Being able to locate the super star made me happy because it caught my eye then I was able to look it up and define it. Locating Orion was less notable because finding his belt is usually easy. Overall I enjoyed finding stars and learning about	
37	I love looking at the stars in the sky and it was much fun to use the sky apps to spot constellations. I always look for the Big Dipper first and Orions belt because those are stars I have known my entire life. I also saw Cepheus. It is hard to view much in the city of Denver though		I grew up stargazing and its such a helpful relaxing activity.
38	Saw Orion, auriga and Gemini	Seeing the stars and constellations made me excited that we can still see some stars in Denver even though there is a lot of	
39	I saw a very faint appearance of the little dipper along with many planes	Finding these objects or rather the lack of finding others, honestly made me feel a bit sad. I feel like I should've been able to see more stars but even after waiting for my eyes to adjust I could only pick out the little dipper.	
40	I could see Sirius near the horizon and the constellation Canis Minor	These are fairly bright stars, makes me sad that there is so much light pollution that other stars aren't visible. Light pollution has negative impacts to the environment and human health.	Denver is rapidly growing in population, as there is more infrastructure being built. Light pollution will become even worse in the near future.
41	Saw the little dipper from Boulder, waning gibbous moon	Seeing the stars made me feel calm that night especially because I was having a rough night I felt more relaxed	

42	saw Orion and Gemini. First time using an app that I could point at the sky and they could show me what it was that I was looking at	Felt good, very cool and regret not having used this resource before to help broaden my knowledge on constellations.	Neat activity, the use of apps for identifying celestial objects is very neat
43	I saw Venus this night	I always think its really cool to see other planets in the sky because they're not always visible.	
44	I spotted orion's belt and the big dipper. Moon is a waxing crescent. Other small stars and very few clouds	I feel like more stars should be visible, and constellations too. But similar to how the night sky looks in Washington state suburbia.	I'm glad I can see some stars in Denver, but compared to how many stars should be visible, it's a sad reality we live with.
45	Orion's belt	Wished I could see more of the constellation. There were only a few bright stars otherwise, and there was a bluish yellow haze around the horizon. There weren't any clouds and the sky seemed clear, but the building silhouettes and streetlamps of my neighborhood limited how much I could see. After spending the fall on Field Quarter and camping under insanely bright, open skies, I was sad to not be able to see the same things back here in Denver. Living in a residential neighborhood near a large	The light pollution in Denver is so depressing. My friends and I fondly refer to the reddish yellow haze that the lights in the DU neighborhood create as the "yellow orb". Reflecting upon this, it's a way to acknowledge the problem and bring awareness to the issue through a semi-humorous way.
46	Big dipper	made me feel kind of connected to home and nostalgic for home because I can always pick it out easily at home.	The stars here are a little bit saddening compared to at home because there is so much light pollution
47	Ariuga, Orion's belt, Rigel, two of gemini (castor and pullox), sirius	Using a star gazing app, I was able to identify more constellations than what I would have expected of myself. It was exciting, fun, and a quite enjoyable experience overall. I felt calm and peaceful.	I really enjoyed this! It only took a few minutes of my day, but even a little bit of time enjoying the beauty of space resulted in me feeling much less anxious and much more grounded. I used to star gaze much more frequently when I was younger, and this experience reminded me of why I love it! Furthermore, this activity reaffirmed my preference for night--I don't know if it is the dark, stillness, or stars, but nighttime has quite a meditative effect on my disposition. I'm glad I was asked to do this, as it will definitely become a part of my routine moving forward. I feel like I have rediscovered a hobby!

48	While stargazing in Syncline loop at the Upheaval Dome backpacking looping in Canyonlands National Park	I looked up to view the stars. Delighted to see this I spent hours gazing upon the desert open sky. I saw constellations, the big dipper, Orion's belt and so on, but many more satellites moving in the sky. There is a certain openness I felt being in this area, yet the satellites involved in this experience contrasted this with a certain closed-in feeling I felt from these satellites looking down	I quite enjoyed this.
49	The constellations Orion and Taurus were seen from the North West. The constellations Southern Cross and Virgo were facing South East. A couple of stars were also viewed from Anstey hill, including Pi Puppis, Epsilon Muscae and Tau Puppis.	Finding these celestial objects has made me feel a greater sense of gratitude and happiness in my life. This is because looking at the stars has helped me forget all of the stressful activities throughout the week, such as casual work and Uni. It also helped me develop a higher interest in astronomy since I was learning the names of the stars and constellations that I saw in the sky. Watching constellations and stars in the sky had brought me a big smile on my face because I learned that the stars are bright and spectacular to look at even though they are	Observations 1 & 3 were investigated in Anstey hill. Observation 2 was observed in my backyard in an urban environment.
50	I observed a satellite moving across the sky. I observed the constellation of Crux and its two pointer stars. I observed Orion's belt.	Finding the celestial objects reminded me of how much infinite mystery surrounds us. When we go outside for the night we are missing out on our connection to the broader cosmos in a kind of "out of sight, out of mind kind of way." I feel sad that I don't look at the stars all that much and I wonder how spending every night under the stars made my distant ancestors feel.	This has been a good opportunity to learn more about the stars. While there are a few that I can reliably identify I am now interested in trying to identify more when I go outside at night.
51	We saw Orion's belt with the star Bellatrix below it. We saw the Southern Cross and the Milky Way.	We visited Anstey Hill Lookout to make our observations. The day we went was more cloudy than we had hoped for, which was upsetting. What also affected the visibility was the trees and light pollution from the city. When I compare the sky near the city to when I am camping it isn't the same. I like to think of each sunset and night sky as new paintings we get every night. Next time we plan to go north to the flat plains so we are further out and have a greater field of view. Something I pondered while out was whether the little amount of time we spend looking at the stars is due to the pace of our lives or the reduced visibility of being in the city. I felt that having others there reduced my ability	I need to have learned more about the night sky before I can begin to appreciate it regularly.

52	3 shooting stars, southern cross, pointer stars, milky way, satellites.	I think it is first important to know that this stargazing session was whilst camping on kangaroo island. The night was very clear and the stars were incredible, as soon as it became dark i was in awe. I felt very content looking up at the stars that night. I was very relaxed with my focus purely on the stars somewhat in a meditative state. I felt connected to the land in that moment that i was small, a small part of the universe rather than the centre of it which is easy to catch yourself doing in the stresses of every day life. This feeling of being small also made my	I only really stargaze when I am away from home, in areas that are not saturated by light pollution.
53	Moon, International Space Station, Crux, Carina, Orion,	The overwhelming feeling I had when looking at the stars is a sense of smallness. Not in a scary or insignificant kind of way but rather an appreciation of the enormity of the universe. I begin to picture the fact that the what is visible is just a small fraction of a galaxy that is itself just a tiny fraction of the universe. Out of all the experiences with nature, observing the constellations and man made objects in the sky is by far the	
54	i saw the the big dipper, the southern cross	i found it honestly a little scary for me i've always been slightly scared of the dark, staring at the stars and seeing this big open space is crazy to me. at the same time it beautiful it was a clear night and i stood there with my partner and point out different things it was a nice moment. its really made me think how small	i really liked this exercise i never thought of stargazing as a form of relaxation
55	•Full Moon •Sirius (at bottom of big dipper) •Big dipper •Southern Cross •Canopus •b Centauri •Alpha Centauri •Space station moving •Betelgeuse •Milkyway	As I laid on the beach at Largs Bay, I felt relaxed and I sense of peace. Living in the city suburbs, I don't really get to experience lots of stars in my backyard. Although I didn't see that many down at the beach I was able to till take it in and realise how small and precious we are in the gigantic universe that God created. It made me realise that if God can create the stars and put them in the exact place, then he knows everything about me and knows the plan he has for me. It was also an amazing time to spend with my mum and sister and just being in their	I did complete another session at Mannum at Palmer Hill lookout. It was a (almost) full moon and I saw •Milky way •Southern Cross •Triangulum Australe •Source pan •b Centauri (pointers to the cross) •Alpha Centauri (pointers to the cross) •Sirius (Brightest star) •Puppis •Big red star •Centaurus

			There are many factors that go into star gazing with being overstimulated, but i belive the experience is heightened when you are with others and if its with someone who knows stars, it makes it go for longer and so much more relaxing but exciting at the same time.
56	stars and maybe a couple satellites, i saw the north star and the three stars in a row	i felt curiosity with what i found and saw, but there wasnt much there to actually see, there is little light around and minimal city glow but the sky still looked a little empty, but it still felt very calm and open	
57	Stars and aeroplane (non-celestial objects)	Nothing special. It is not as bright as I saw at Kangaroo Island. On the night when I saw the celestial objects listed above (Moon, Orion, Crux), I was camping on the riverbank in the backwaters of the Murray River (Camp 10) near Lake Bonney in South Australia. I saw the moon rise in the late afternoon while canoeing, on the last leg of the day. By the time the sun set and the stars came out the moonlight was quite strong, and only the brighter constellations were visible (like Orion and Crux). The bight moonlight allowed me to walk around my campsite without a head torch, but it also cast the landscape into strange shadows. Seeing the moon rise late in the afternoon filled me with nostalgia and made me feel almost migratory, like I needed to leave, and travel north, or make some kind of radical change. I also felt a kind of relief to see the moon and stars, and recognition, and was grateful for the light of the moonlight that helped me see my way. I was also glad to see the Crux because I knew if I got lost it would help me to navigate. Seeing Orion setting, emphasised the changing of the season and contributed to my earlier sense of nostalgia. I also felt a bit annoyed at the overbearing moonlight, because it meant I couldn't see as many stars. The strange shadows cast by the moon also gave me a bit	
58	Waxing gibbous moon, Orion, Crux		I am lucky to live in a place where we can see the stars, and to have had many opportunities for stargazing in my life. I hope that all people in all places will have the opportunity to see the stars, and that my grandchildren, and their grandchildren, will be able to go stargazing too. Dark skies are so important for the world, thanks for your hard work!
59	orions belt, southern cross, milky way,	how far away everything is, how small we are and how appreciative of the log scale I am	the "made you feel" question isn't clear to me. I don't understand what this means or maybe I'm just not in touch with my emotions
60	Iron pot, Orion belt, variety of star sizes	accomplished, small, peaceful	

61	Sirius, Gemini, Hubble Space Telescope, Bellatrix, Canopus, the Moon, Leo, Spica, Rigel, Hadar, Southern Cross (Gacrux, Bacrux, Acrux, Decrux), and Regulus	Using the app (SkyView), I was blown away whilst reading the descriptions for some of the stars. The distance away, the size of them, and facts about whether they were binary star system or sometimes more were very interesting. Unfortunately tonight is only a few days away from a full moon, and the brightness definitely prevented me from seeing a lot more.	
62	saucepan/ursa major, milky way, southern cross, scorpius,	It made me feel at one with the earth but also reminds me of how small I am in comparison to the earth, and the galaxy beyond. It also reminds me to play my part in making the world better, even if I am so small and there are so many of us on the planet, any effort to try and heal the world is worth doing.	
63	As it was a cloudy night I only saw two stars, both I could not identify.	Seeing the stars made me excited, I felt that I developed more of an appreciation for the beauty of nature.	You spelt third wrong :) see above^. I enjoyed viewing the stars for this and I think I will make it a pastime from now on, this assignment has helped me to appreciate the sky and what it means to us.
64	orion, vega and others constellations, the moon, one meteor shower, star clusters	I feel free and happy also I feel that I was flying in sky and bringing peace in my heart.	after this experience I felt that peace and help my stress etc. which is same as meditation. Hope this exercise will help many people with mental health and stress etc.

65	milky way, southern cross, the pot , satellites,	I have completed stargazing many times while on outdoor journeys at night time but in relation to my first document experience this is how I felt. As a whole stargazing as an experience always makes me feel a similar way; I always feel small, and I always feel some sort of existential dread. Whenever I look up at the stars even for a small amount of time, I can always picture how small the earth and all the stars are, and how small we are as a race and as a world. This star gazing experience was no different, as I pondered the significance of the human race and each individual human in general, as well as picturing the surface of each star, the terraforming of each planet and what kind of different undiscovered life or minerals or different formations and imagined what the sky would look like looking up from each planet's surface. I after the initial shock of our life's insignificance and our smallness I was however overcome with an absence of stress, and an overcoming sense of peace, which is quite contrary to the existential crisis I previously experienced. The peace, which comes directly after is not something that I intend to feel or something that is planned but rather something that overcomes me; at a subconscious level I think to myself if we are so insignificant that we are but a speck of dust to the rest of the universe, why worry? Why stress? And lying there, with all these thoughts rushing through my head comes nothing but a deep	i think this is a great study and I found the videos amazing but I did not apply then to my observations as now reflecting back I wish I would have
----	--	---	--

66	the Iron pot, Orion's belt, Southern Cross, seven sisters	As with each time I find one of the constellations in the stars, I feel very satisfied that I have been able to distinguish something specific in the vast array of stars burning above us. When looking up at the magnificent display above, it always makes me feel incredibly small and insignificant, and it helps me to remember that we as humans, are rather unimportant and insignificant compared to that of the earth, and that of the universe. It makes me wonder how we came to thinking, and how we continue to think that we are so much more important than the earth and its other inhabitants, that we should just do whatever it is that we want, regardless of the cost it may have on the earth. Looking up at the sky at night, away from the sounds of traffic, seeing all the stars, just makes me feel so much more connected to the earth and universe. I really want for light use to be reduced so that the skies can go back to a somewhat closer version of what they used to be, and so their beauty can be enjoyed so much more than what it is able to be at the moment. It would be amazing to be able to see more constellations more vividly, as well as the ones that are just not visible due to the light pollution, as while they are much clearer	
-----------	--	---	--

The moon in Waxing crescent phase Cancer constellation- faint stars close to moon, two upper case Y connected together representing the crabs' eyes at one point and the legs at the fork point Southern Cross (Crux) and the Pointers (Alpha Centauri)- found in a navigation exercise on camp to find the South on the Horizon. Southern Cross had 2 bright stars in the 5 grouped closely together this made it easy to spot the Pointers as the constellations were beside each other Gemini constellation- located near the moon it looks like two stick figures dancing at the bottom of the Milky Way. The dancer's heads are marked with two brightly coloured stars and bodies stretch above the moon. It is a bit difficult to spot. I saw a object moving in a straight line similar to a space shuttle of some sort but no one	This was my second time camping in the Coorong. The serenity and lack of light pollution made viewing the stars easy as it was accompanied by a presentation on constellations and a Dreaming story. Whenever I look at stars it reminds me of being a little kid and playing eye spy in the sky. Looking in a group made it more of an experience to remember we all tried to find our star sign. Mine was Cancer and my group partner was a Gemini. I was able to spot mine quite easily as I used to have a telescope and mum taught me to find it when I was little. We used a star map to find our constellations there's something special about camping and star gazing. In our navigation activity we all located the Southern Cross and used it to find south this is a technique I hope to share with school group in the future when I'm a teacher as it's really cool to be able to know where you are without using your phone or a map. I think people often forget how much living in a city takes away from the stars as whenever I go home to Port Lincoln or go out camping, I'm surprised at how bright everything is and all the different constellations you can spot. The Dreaming story made me feel a connection to the land and objects around me this was a great basis for the viewing session and made me reflect on my own heritage and connection to Country as Polynesian people were some of the best Celestial navigators for their long voyagers. I	
67 knew which one it was	Finding the celestial objects made me feel calm and brought about a sense of wonder. Being able to distinguish the different was an exciting feeling	
68 Southern cross, Betelgeuse/orion,	On this night, I was driving home from uni with a friend and we realised how beautiful the night sky was. When I got home I decided to take my first observation for this task. It was a bit too cloudy and there was too much light pollution to see many stars, but the moon was very full and clear. It was very captivating to look at the moon and think about how small I am in comparison to the rest of the universe. and how small the moon is in comparison to earth and so on. It really puts things into perspective even for just a moment. I felt a great sense of	
69 The Pink moon,		

70	Constellations - southern cross, Sirius (brightest star), Orion, Canopus, Centaurus, Leo	Finding the celestial objects made me feel enthused and excited to continue identifying objects and learning new things. It was a very calming experience and it was interesting to identify the effects of light pollution whilst undertaking this activity. By continuing to let my eyes adjust to the darkness in the sky, I was able to identify several objects and could understand the effects of light pollution. It was interesting to identify constellations during the later parts of the activity, compared to at the start when my eyes were unable to penetrate many of the stars in the	
71	From my home, I did not see a lot. I could see the moon and a few stars. I think I could see the star that is mars as it had a red hue to it.	It made me feel a bit disappointed knowing the potential that it can be but due to being located in a suburban area, lots of noise and light heavily impacted what I could view that night. I always have enjoyed looking at the night sky and it is one of my favourite things to do while camping. So again, knowing what else is out there and the potential it should have is very sad to see how	

ID	feel2	obs2
1	I was confused at first because I wasn't expecting a satellite to be so visible, but afterwards I was really impressed.	We saw a satellite using a stargazing application.
2	I was glad to see more this night. I went to a nearby park in hopes of seeing more and was pleasantly surprised to be able to see Orion's belt and the Space Shuttle.	the Big Dipper, Orion's Belt (faintly), and a few airplanes
3	I feel this is very amazing because	polaris is the brightest star in the sky.
4	Doing the star gazing so close to the other episode (1 day away) made me feel even more insignificant in the grand scheme of the universe.	Mars (I think), Orion, ISS and Polaris/Ursa Major
5	Finding very few stars and mostly glares from the light made me feel sad because we should be able to see more.	Just a few stars a light glare
6	For the one that appeared, the same as yesterday. It shown just below the clouds. While there were other stars semi visible, they did not form a constellation. Instead, they were fade like and barely visible (which was disappointing but fair).	Bellatrix, Waxing Gibbous moon (covered by clouds but seeable), cloudy
7	I felt more connected and smaller as i was doing this activity with my grandma and we talked about how small we are in the scheme of the universe	Same objects as last time, except in my house there is less light pollution so I was able to make out more constallations like Draco, anooother one of my favorites, ursa Major and Minor, and of course the moon, I could be wrong but I do not think any planets were especially visible that night.
8	It made me feel like wanting to observe for longer and get a telescope out.	Orion's Belt, Venus (most likely), the Moon.
9	It is calming to look at the night sky, but less so when there isn't much to see. I felt less connected to nature than I had in the past, since I was not seeing what I had expected to see.	Stars, planes, and satellites.

10	I saw the moon, Orion's Belt, the Big Dipper and the Little Dipper. Of them together made me feel really happy because I know that Orion's Belt has history from Egypt that is related to the 3 pyramids which I find interesting. Also finding the big and little dippers is also fun because they are easy to find and it is cool to see all of the different constellations in the sky.	I saw the moon, Orion's Belt, Big Dipper and the Small Dipper.
11	As mentioned yesterday, I found this exercise to be quite grounding. It's incredibly important to pause every now and then and appreciate one's surroundings. However, the amount of planes I saw within this observation reminded me of the unnatural objects that take up space and time and disturb the natural environment.	In pausing for 10 minutes, I saw three planes move overhead. This is a common occurrence, as I live in Denver, CO and there's a great deal of air-traffic. Their bright light guiding their way and alerting surrounding planes is what drew my attention to their place in the night sky.
12	It was not as clear as the night before, so I felt slightly disappointed, but it was still very peaceful	Satellites, a few stars, and the moonlight (the moon was covered by a cloud)
13	Again, it made me feel calm. It was a nice time to clear my head and think as I looked above me	constellations and the moon later that night
14	They made me feel sad that we are not doing as much research as we should about these different celestial objects	I saw some stars that were brighter than others and some stars that were more dim which made me interested in why this is.
15	it made me feel good to find the constellation again. I wasn't throwing my fists in the air like I won a great battle or anything but it was nice to see that I remembered how to do something I learned in elementary school. I guess I was proud and also in awe because it is fun and relaxing to look at stars.	The Orion Constellation.
16	I felt calm and peaceful finding the celestial objects. Felt very nice to sit outside and look up at the sky.	Only saw stars and the moon tonight
17	I felt kind of scared. I was walking home and gazing up and it was really dark in the alley way that I was viewing in to get back to my house.	I was trying to find constellations but it was really cloudy and hazy so it mostly just looked blue.

18	Although I was underwhelmed as my view was not as picturesque as the previous night, it was still an enjoyable process of leaving my dorm at night, looking up above and letting my mind wander. Again, it was meditative for me - I felt calm and content.	This night, I intentionally observed the stars earlier to see if there would be a significant difference in my findings. It certainly was lighter than the previous night, however because I was viewing from campus (outside Nagel) I'm not sure if light pollution was a potential confounding variable.
19	Again it made me feel really good.	I saw another constellation
20	I went for a run with a friend and it was quite hard to spot stars unless they were very bright. I couldn't find either of the dippers which was sad	A saw the brightest stars, which was maybe less than 10 and that was it.
21	It makes me feel small.	I saw an airplane in the sky. It was heading due east.
22	I felt great. There were not many celestial objects that I could see, but the weather and the clearness of the sky made me feel at peace.	I didn't really see anything tonight. The stars weren't out or very bright. It seemed as if it was cloudy to my understanding.
23	It made me feel very small in the grand scheme of things. It made me realize how big the world really is and helped me put certain things into perspective. Humans are such a small part of the world.	The north star
24	The sun made me feel warm, and the sunshine from the sun made me feel happy and gave me energy to want to go outside and be in the sun.	sun
25	Calm, at peace, happy	only a couple random stars, moon, and several airplanes
26	It was nice to see Jupiter since I don't really get to see it or find it for most of the time. Using the app definitely helped.	It was a bit cloudy however I was able to see the big dipper, the moon and Jupiter.
27	Today was a bit cloudier, had to kind of wait for the clouds to part to even get a good glimpse. Once I was able to find Orion, I again was humbled and taken aback at the beauty and mysterious nature of the constellation. It's wild to think about how those tiny specs of light in the sky are actually massive stars millions of light years away.	Orion
28	I felt small looking up at a little bright burning, it looked so far away but I could still see it so far away	I saw a very bright star that i am guessing is some kind of burning celestial object

29	Its my favorite constellation and it made me feel happy to be able to find it here in Denver.	The Big Dipper
30	I was not planning to be awake this late, but on these nights I often find myself staring out the window, up at the sky. I was not nearly as excited about the space shuttle than I was about other observations, but it was still interesting to see, although it was also very difficult to see.	It was very difficult for me to see the space shuttle as it was very cloudy, but I knew it was there when I saw small lights blinking in the sky, and no airplanes would be flying at that time. I have seen the space shuttle before, and to me it looks like a small speck in the sky, but it is still interesting to see knowing what it is.
31	Again I felt relaxed and distressed while looking at the sky	Unknown stars, and a waxing crescent moon
32	They made me feel as though there was potential for discovery in our solar system. I reflect on this and question what else is in the sky	It was cloudy, hard to see constellations, but I did see the north star
33	It made me feel small. It made me feel like nothing matters and that I am just a tiny speck in the universe. But it was kind of comforting.	I saw a few airplanes (not necessarily celestial but in the sky), I saw a lot of stars and a few constellations I knew, and I saw a blinking light but I'm not sure what it was.
34	Big Dipper	Made me feel excited, happy, and proud; I haven't ever seen the Big Dipper previously, so getting to see the famous constellation in the sky made me extremely happy. I was also very proud of myself and happy that I was able to find this constellation without help from another person.
35	It made me feel like I am so small in a world that is so big. It made me realize that I don't really matter, in a good way. I attached a link to a video of the meteor that I saw, I guess someone got it on camera. (https://gazette.com/meteor-over-arvada-colorado---feb-18-2022/video_c4f426aa-91f5-11ec-8ecf-23e94197aa79.html)	I saw either a really long shooting star or a crazy meteor looking southward from Denver.
36	While I was disappointed by not being able to locate anything, seeing a full moon always makes me smile because the moon cycle interests me and I associate the moon with good memories.	I was not able to make out any constellations or space shuttles this night because the moon was nearly full.
37	I saw the Big Dipper again and Orions belt. I saw Casseopia.	It was a bit cloudy, so it was harder to see as many stars as the night before, but it was still a nice night. Since there was a new moon, there were the ability to see a lot more stars than if there had been a full moon.

38	but it was still cool to see some of them.	Saw parts of Gemini. This time, I was unable to see as many stars, which was unfortunate,
39	Everything I thought was maybe a star would end up being a plane. This made me feel honestly quite shocked as I couldn't pick out even a singular star in the sky. However, I thought I could maybe make the outline of a cloud-like shape so that might have had an influence on the fact that I couldn't see stars.	I could not pick out any objects in the sky other than planes.
40	Made me think about a camping trip I went on near Buena Vista where we were able to see many stars in the sky along with the milky way. It's unfortunate and heartbreaking we can't see that here.	he star I could see the best was Sirius. This is one of the brightest stars in the sky, difficult to see others this night.
41	Made me relaxed and tired because of the calmness of the stars.	Think I saw Orion's Belt, Moon still waning gibbous, fairly clear skies.
42	Again, finding these celestial objects made me feel good, but also makes me feel a little weird and very small looking up at them.	saw Leo Taurus and Orion, well more or less saw them, the app pointed them out but not really as on the app.
43	It felt cool to look for new constellations because I can only recognize a couple of them	I saw Canis Minor this night.
44	It felt anti-climatic because I expected to see more stars. One streetlight made it significantly harder to make out stars. No clouds but also no stars.	Big dipper, only 3-4 other stars visible, spaced far apart. Moonlight present.
45	On my walk home, I noticed a majority of the houses on my street have yellow tinted porch lights, and we don't have any streetlamps. When approaching my house, I realized the LED lights in our kitchen are really bright, making it easy to see into our house, but also shine light into our front yard. It looked like our house was glowing blue under the yellowish sky.	There was a snowstorm, so there was a lot of cloud coverage. There was an eerie yellow glow and it's always so much brighter when there are clouds compared to clear nights. It's like the clouds blanket the city and lock in all the light.
46	it made me feel fascinated. We can use technology live to identify constellations that I don't know whereas people used to use the stars for navigation.	cassiopea,

47	Similar to the last time, this was also a fun experience for me. I never realized how much I enjoyed stargazing until doing this. I think a lot of that enjoyable, and in some ways sense of accomplishment, comes from the fact that each night I was surprised to not only identify stars without the app, but identify new constellations I had yet to see.	Ariuga, Orion's belt, canis major (sirius), Rigel.
48		I mostly saw satellites and bright stars that could peak through the Denver haze. !After many foiled attempts at stargazing only to look up at a cloudy sky I finally got a clear enough night. The only problem is he huge amount of light pollution that infiltrated around me in this urban environment. They made me feel good knowing something was out there but reminded me of the ecological impact that this city puts around us.
49	Today, I was once again feeling joy from my beating heart in spotting the stars. However, I was also feeling annoyed and sad due to light pollution's effects on the night sky. This is because it was challenging to spot the stars at night since the night sky was extremely cloudy. This situation may have occurred since observation 1 of my research involved looking at the stars from Anstey hill isolated from urban areas. Today, I was looking at the stars from my house, which is located in an urban environment.	I saw the Orion and Gemini constellations and the Canopus star which is the second brightest star in the night sky.
50	It made me feel calm. It made me a kind of kinship with the cosmos and the reality that all living things are contained within the thin layer of atmosphere surrounding this earthly sphere floating in infinite space.	Crux, Beta Centauri and Alpha Centauri, Sirius (The dog star), Canopus
51	This time I went with fewer people, just myself and one friend. I felt small in the grand scheme of things. A part of a network so far beyond my comprehension. Whether that is a positive or negative outcome, I am not sure. I also thought about how the light we see from stars is lightyears away, so I was effectively looking at the past, which is always a daunting realisation.	I knew only of the same ones I knew before and I saw them again. Oriens belt, Bellatrix, Southern Cross, Milky way.

52	Again I was on kangaroo island away from all light so the stars were very visible. This stargazing session was more so led by curiosity rather than by feeling all peaceful and relaxed. Looking up at these little lights in the night sky made me think deeply and ask myself many questions. I saw 11 satellites, how many are there I asked myself? I thought about the fact that the closest visible star is 400 light years away and the furthest is 4000 light years away. I tried to fathom how far that really is. Although impossible it still made me feel very small. I then thought about what else may be out there. What other life? I am under the impression that because the universe is never ending you would be naive to beleive that we are the only form of life. Although this is not something i often think about these days so it was nice to reconnect to this thought and realise that we are not alone in the universe.	I saw 11 satellites, southern cross, 'saucepan' consterllation, milky way and 4 shooting stars.
53	I felt a sense of peace and calm during the whole exercise. Observing the constellations once again made me feel really small and began thinking about the immensity of the milky way and beyond.	Crux, Canis Major, Orion, Sirius
54	my second viewing was camping at the yorke peninsula it was amazing seeing how different and how bright the stars and moon were in comparison to the city, i felt right at home, the stars were pretty and i enjoyed having nothing to do a night but star at the big open world from the comfort of my tent	almost full moon, slight cloud cover, bright stars dont know what certain star collections were called but enjoyed staring at the stars, saw a plan fly over

55	I decided for my second star gazing session that I would do a park near my house in the suburbs to see how different the night sky would be. As a result of this park being in the middle of the suburbs, it was heavily affected by the light pollution by the surrounding street lights. This affected my vision to see colours in the stars and also meant I couldn't see some of the stars I could see at the beach. This made me feel a bit upset because such a beautiful and wonderful experience was lost or heavily impacted due to human development and it can be robbed from some people if they don't go away from the city to experience the night sky. I did however spot a new star formation which made me feel very excited and a bit proud of myself for finding and identifying it.	•Milky way •Southern Cross •Triangulum Australe •Flashing star close to horizon •β Centauri (pointers to the cross) •Alpha Centauri (pointers to the cross) •Sirius (Brightest star)
56	i felt really peaceful, happy that i could see so much but wanting to see more, seeing a small amount of space dust made me want to go out far into the country and see what more i can see and experiences, i felt calm mainly, but i think having the clear and cool air helps with a full body sensation	a bit of space dust which i believe was the milky way, various flashing stars which im pretty sure are satellites or shuttles of some sort, the main bright star and the three stars in a row, with so many stars in view i felt with my vision they all mixed a little and was hard to 100% know what the star or constellation was
57	Nothing special. Same as the observation at day one.	Stars and aeroplane (non-celestial object)

58	I observed the constellations listed below while camping at Chalks campground in Mount Crawford, South Australia. There was no moon, so the stars were bright and the Milky Way was visible. Sirius and Canis Major were visible slightly to the NE of the zenith and Orion was setting behind a huge river red gum. Crux was rising behind another tree. I could also see Canopus slightly to the South of the Zenith. I was excited and happy to see the stars shining so brightly, and to see the Milky Way. It made me miss my husband and daughter. I wished they were there with me, so that I could share the beautiful night sky with them. I made up my own constellation from the a pattern of stars that I could see, and called it the seahorse, because seahorse fathers look after their babies, and my husband was at home looking after out little girl while I was out in the field. I felt physically cold, and generally philosophical. The constellations reminded me of many stories, both from the Dreamtime, and from western mythology, and I felt strongly connected to the storytellers of the past.	The Milky Way, Sirius, Canis Major, Orion, Crux, Canopus.
59	Living in the city that's night sky is saturated with light pollution makes it hard to see constellations so driving a distance is favourable to get most out of the night sky which is nice but painful just to get somewhat of a better view.	Crescent moon, orions' belt and southern cross.
60	insignificant, contrast between everyday and the unfamiliar	stars, streaks from clouds, Iron pot
61	It was calming. The first observation was just before a full moon and a lot of things were washed out by the brightness so it was worth waiting a few more days this time as the Milky Way was just observable one my eyes adjusted.	Many similar from the first time but new additions were Avior, Aspidiske, K Vel, Miaplacidus, Alphard, Algieba, Suhail, (pie) Hya

62	I was in Bairds Bay during this viewing, so I was feeling very thankful to be in such a beautiful place. I was also in awe at how many stars I could see and made me aware of how much light pollution effects the stars. I felt happy, amazed and inspired whilst viewing the stars. I was also teaching other people to find constellations (the ones I know) and how to find south using the southern cross so I was happy I could teach other people some skills.	milky way, saucepan, scorpius, southern cross
63	Seeing these constellations and being able to identify them made me indescribably happy. I was in awe of the stars beauty, felt a greater appreciation of nature and a strengthening of my bond with my surrounding environment.	I saw what I identified as the Canoe, using Indigenous constellation knowledge, and later came to know as Orion's belt. I also saw Crux, or the Southern Cross, as well as Sirius of Canis Major and the star, Achernar.
64	I felt peace in my heart and help out my stress and depression.	The moon, all of different constellations, one meteor

65	The second time I completed the star gazing I did it with my partner and we laid on the driveway and were looking up at the satellites and discussing what they actually do because neither of us knew at the time until we researched afterwards. We decided at the time to put phones away to ensure we would get the most out of the experience. while looking up we both saw a glimpse of a shooting star and for me that was the first time I've seen one before so it made me feel quite enthusiastic because I never thought I would ever see one. From there we discussed how fast that would have been travelling and wondering if anyone else would have been looking up at the same time we were. This then led to the discuss brought up in the previous stargazing of how small we are in comparison to basically everything and there is so much more to discover that in our lifetime we may never learn about it. we spotted the southern cross and the pot in the sky and pondered whether one day we would look up and one of the stars in these constellations would burn up and explode and how sad that would be because as they have so much history and significance. From there we laid in silence for a while and reflected on our thoughts and discussed with one another how relaxing it is and then eventually got cold and decided to go inside	milky way, southern cross, the pot, 1 shooting star, satellites
----	---	---

66	When I looked up, it actually made me gasp at the absolute beauty of it. Compared to what I have been getting used to seeing in Adelaide, there were so many millions of stars visible to see, and they were so much clearer as well, which I've really missed. It made me feel as though I was in another world, and all there was, were the skies and I, along with a huge sense of peacefulness. No sounds of traffic to disturb it either. Considering there is a slight bit of light pollution coming from town, which is approximately 35kms away, I just wonder how incredibly amazing it would be to view the stars and constellations with no light pollution at all, just as they would have looked before electricity was used. It also makes me feel incredibly grateful that I live somewhere that it is possible to see the stars so well, and also feel so sad that there are people in the world who have hardly ever seen the stars. It's also so satisfying to be able to see and identify the different constellations in the sky.	Milky Way, Iron pot, Orion's belt, pointer stars, Southern Cross, Magellanic Clouds, Mars (?)
----	--	--

67	Tonight, I showed my cousin how to find the Southern Cross and explained how it helps people determine direction. It was good to apply something I learnt in a practical sense, and he thought it was awesome. My family went to the Port Lincoln National Park over Easter, so it was the perfect opportunity for star gazing as it is one of the best places in the Southern Hemisphere for it. The telescope made it a lot easier to see what was out there and it was fun to show people how to use it and spot different constellations. This time I tried to spot ones I hadn't looked at before or find out what defining features were such as the brightest stars in the night sky. My cousin had many questions about what each constellation meant so we googled them when we got home the next day and used the telescope to try applying the knowledge we learnt. Each family member chimed in on things they knew when camping it was quite special. I've noted each time I've done this it's been a relaxing experience and brings everyone together. Using the mobile phone app took away from the experience a little as I feel it was nicer to have uninterrupted time without technology in the first observation, but it also made it easier to spot different constellations. You realise how insignificant you really are looking into the sky, and it made me think of this thing I saw as an ad on social media about buying a star. After some research I think I'm going to buy my cousin a star as they enjoyed looking at them so much, so next Easter we can spot it in the night sky hopefully it will be a core memory they can share with someone else one day.	Using telescope: Full Moon in Virgo. Southern Cross (Crux) and the Pointers (Alpha/Beta Centauri)- was overhead with the Pointers to the southeast. There were some clouds, but the bright stars and cross formation could be seen easily. Sirius (brightest star in the night sky) in Canis Major- located directly on the West horizon it looks like a skeleton dog with Sirius located at the chest and a cluster of bright stars located near the tail and upper legs. This is just under the Puppis (deck) in the Carina constellation. Canopus (second brightest star in night sky) in the constellation Carina (ship's keel)- this was the first-time spotting using a mobile phone app. It was located directly South on the horizon and had 3 cluster points one being the sail cluster (Vela), the second being the deck (Puppis) which jutted out and lastly the ship (Argo) that was a U shape of connecting stars. The Milky Way was visible in the Port Lincoln National Park but the moon made it not so bright.
68	finding the celestial objects made me feel in tune with the environment and more connected to the natural world.	alpha centauri, moon in waning gibbous phase, telescopium?

69	Finding celestial objects on this particular night was very fascinating to me. When I first went outside I was pleasantly surprised that the sky was clear, as it had been quite an over cast day. The first celestial objects that I was able to see was the southern cross and centarous. These stars were quite bright and easy to see. It was quite difficult to see many stars clearly enough to identify in the first 10 minutes as my eyes hadn't adjusted. I could not find the moon which left me feeling extremely confused, and I learnt that night that the moon was not to come out until midnight. As I continued the gazing, I saw 4 planes, which I also learnt can be distinguished from a shuttle by the flashing lights. I found this experience to be very educational, and really easy to get lost in doing. The more I looked at the sky the more questions I had, and it was very satisfying to work out the answers. As I was about to get up to go inside and escape the mosquitos, I saw a shooting star which was the cherry on top of the evening, and I felt like I had seen something very special.	i saw 3 planes, crux, rigil kentaurus, centarous, musca, shooting star
70	Finding the celestial objects made me feel curious and enticed to find more. I used the star map and an app to aid in identifying celestial objects. However, there were some inconsistent clouds within the sky which made it difficult to identify objects. By waiting outside longer, the clouds were able to pass and the objects could eventually be identified. Although it was cold outside, it did bother me as the stargazing experience was calming and exciting. I was able to disregard feeling cold as I was distracted from the activity.	Sirius, Canopus, Procyon, Cancer, Leo, regulus
71	I was again disappointed as it was a cloudy night. It felt nice and comforting to view at the sky and not think about anything else and I really appreciate the stillness compared to the busy street.	Since it was cloudy I did not see much except for a few stars

ID	feel3	obs3
1	Relaxed.	Orion's belt again. Once you find it you never unsee it.
2	I went back to the same park and was ecstatic to see Orion in all his glory and did not realize how large the constellation blanketed the night sky.	I saw the Big Dipper, I could make out the full constellation of Orion the Hunter and I also saw the space shuttle for the first time.
3	Cassiopeia	It is like a reverse E.
4	This time was much more calming than the other two times when I kind of was anxious about how small I felt, but now I kind of feel like nothing matters but not in a necessarily sinacle.	Mars (more certainly this time), ISS, shooting stars (3 of them)!
5	This made me realize that as a society we need to put in more of an effort to curb our actions so we can see the actual night sky instead of having to travel miles into the middle of nowhere to see them.	As the last two nights I only saw a few stars and the glare from the light pollution
6	While it was all cloudy but the moon, it also reflects how bright the moon can shine even when covered (which while noted before, the contrast highlights this).	Moon (covered over); it was cloudy
7	I felt sad because I realized how much light pollution there is here where I live in Denver compared to back home where it is more rural. Still I felt connected to nature if only for a moment in an urban environment.	Saw the Ursas, Orion's belt (and most of the constellation), the moon, and a satellite, and I know they may not count as celestial but I saw 3 planes
8	Excited to identify each object and always wanting to look up each night.	The Moon, The Big Dipper, Mars.
9	Finding celestial objects made me feel a sense of curiosity. Questions like "who is on that plane" or "where is that plane going" or "what does that satellite do" came to mind.	Stars, satellites, and planes.
10	How these objects made me feel was amazed because it is also fun stargazing with alone or with a friend. It also fascinates to see and find all of these celestial objects in the sky. Theya are all so close, but yet so far away.	Parts of the Big Dipper, the moon and some stars.

11	Finding the celestial object was both relaxing and inspiring. There's something powerful in being able to recognize aspects of your surrounding environment! It prompted reflection within me.	This evening, I observed one, large, bright star above me and to the right when facing the mountains. I found tonight's night sky to be a little more calm and it took a bit more patient to identify a celestial object compared to other nights.
12	I had this observation at my childhood home, and so it made me feel very nostalgic	Stars, possibly some constellations (I do not know constellations by name), the moon
13	Calm and full of wonder	the stars and the moon
14	It made me feel excited that this was my third day viewing these stars and I was still finding new objects in the sky.	I saw different stars more close together than others and some constellations again that was very close together.
15	It made me feel good. I wasn't cocky or anything after finding it three nights in a row but I was glad. It was nice to take some time to look at the stars.	I found the orion constellation.
16	It felt very peaceful to find the objects, but also frustrating to only see a few stars. I grew up outside of the city and am used to seeing a darker, more star-filled night sky. However, it did feel like a way to connect with nature while in the middle of a city.	big dipper, moon, only a few stars
17	I felt really at peace looking up and outside at the sky. I was with a really big group of people and I had pointed out how cool the hazy blue sky looked and we all felt very connected in that moment.	I saw mostly planes and blinking red lights in the sky. I don't really see very many stars from my house. It just looks like a big blue expanse.
18	The process of walking out a couple blocks late at night was as nice and peaceful as expected, however the plane made me think more deeply about the human impact on our natural environment. This made me a bit melancholy.	To address the previous potential confounding variable of light pollution, I walked a bit further from campus to observe the starts (albeit not as far as Wash Park). My findings were not that different, however the stars seemed a bit brighter (I know I could have been placeboing myself though). A plane flew by seemingly out of nowhere which juxtaposed interestingly with the otherwise quiet night.
19	It made me a bit sad to see very visibility of the stars and of the sky	I saw pure pollution and ash in the sky

20	It's disappointing that I can't look out my own window and see stars unless it is during the very early morning hours, which I'm usually sleeping though.	I looked out my dorm room window and couldn't see anything because the lacrosse game lights were on. Until they turned them off I maybe saw 3 starts
21	It makes me feel glad to see the stars because if it is cloudy I cannot.	I saw several stars but could not make out any constellations.
22	I felt really calm, like all of my anxiety cleared.	little to no stars, partially orion's belt, no moon
23	It made me feel kind of stupid as I didn't know anything about constellations, but also amazed that we are able to see it and that it is actually real. It's easy to forget about stars when they're so far away and you would never be able to see them fully.	cluster of stars
24	finding the celestial objects made me feel happy although sometimes I get mixed up for what is a celestial object and what is not! But when I find a bright star or a looking at the moon, I feel calm.	moon and stars
25	Since there was nothing, I don't think I really felt anything. Maybe a little sad because I couldn't see anything. Calm also	I couldn't see anything in the sky, not even a couple stars. And I assume the moon was there, but I couldn't see it
26	I was happy to see these especially the consolation, since it makes you feel and realize how small you are. Seeing the stars when they are bright is the best feeling. Your mind is able to drift off and it feel like every problem in your life is microscopic.	Ursa Major, The big dipper and Jupiter.
27	I've grown up finding the space station in the sky with my dad, we had an app that would tell us when it was overhead. I'm pretty sure I saw it tonight, either that or another satellite. It amazes me that these giant metal structures are just floating around the Earth. Seeing Orion in the same spot as I've been seeing it makes me confident, I think about the people who used the stars to navigate and can understand how they did it.	Space station, Orion
28	I felt warm inside looking up at so much light that did not come from a man made source	I saw the big dipper, the moon, and little clusters of stars.
29	Made me feel like an astrologer	The moon

30	My whole life I have looked at planets through my fathers telescope, while Mercury was not the most interesting one I have seen, it still felt amazing to make something so far seem so close.	I had gone home for Easter this weekend, and my dad told me that we would be able to briefly spot the planet Mercury overhead. He pulled out his telescope and we were able to look at it closely. I noticed its moon-like features, and for some time, forgot I was looking at a Mercury and not the moon.
31	Relaxed, and a sense of community, as several people were also observing the sky with me	Stars which may have been a part of the Great Bear Constellation, and a Waning Crescent moon
32	They made me feel a sense of hope and that good things were coming.	The moon, it was a clear night, but there must have been light pollution because I didnt see any stars
33	It made me upset that there was so much smog in the air which made it hard to see the sky clearly. I felt the distance between me and the earth and space. I felt very calm.	I saw the big dipper, Orion's Belt, the moon. But not very well because of light pollution and some smog or cloudiness.
34	Made me feel relaxed and at peace; During this night, I did not get to see any particular constellations, but did see many other stars in the sky that still made me feel very relaxed. I also noticed other occasional shooting stars, and it made me feel very at peace. I was overall very intrigued with how the stars lit up in the sky, and even if there was no specific constellations that I could make out, it was relaxing to look up at the sky and enjoy the view.	Constellations, shooting stars
35	It made me feel relaxed and made me realize that all of the things that I do with my life don't matter either. We're all on this planet, and we're all going to die at some point, and that just looking up at the stars or stopping to smell the roses once in a while is a really good thing.	I saw the big dipper and the little dipper from Golden.
36	Looking at stars makes me feel small/humbled in a good way but I could hardly see any so it made me feel a bit sad	I believe that I was able to identify Ursa minor and possibly Orion but the stars were not clear because of the light pollution.
37		It was also slightly cloudy on the 3rd, but I saw the Big Dipper and Orions belt for the third time the clearest. According to the app, there was also a constellation named Draco.

38	It was snowing, so it was harder to see the stars, but I stargazed between a break in the snow and was able to see a couple stars which was very exciting.	A couple stars part of Orion.
39	This made me feel honestly a little bit happy as these were the most stars I had seen over the course of doing these observations.	Once again I could see few stars, however I believe I could see the little dipper and orion's belt constellations.
40	This made me a little happier than the previous night, but still sad that not nearly as many are visible as in a place with far less light pollution.	I was able to see Betelgeuse, Orion's belt, and Rigel. This night I was able to pick out more stars and constellations in the sky, but they are all still very bright stars.
41	the snow with the streetlights was nice and surprisingly relaxing when looking out my window.	Snowy night, cloudy, didn't see many stars or any constellations but
42	Looking at the celestial objects tonight made me eager to look at them later when I am not in Denver in locations where the stargazing is better with less light pollution.	saw Orion and Taurus. Was a bit cloudy tonight so had a hard time seeing much of anything, Orion seems to be the most reliable one for me to be able to locate myself and with the assistance of the app.
43	I had a good time looking for things in the sky and its cool to think about how far away they are.	I saw Gemini this night.
44	It made me feel excited to be able to point out some stars, and the moon was bright and beautiful even though small.	Orion's belt, waxing crescent moon, and Sirius. Clouds present but many stars and moon very bright.
45	My reaction was "Oh, I didn't realize the moon was at that stage". I wondered what it would be like to see the sky without light pollution from the city. There weren't a ton of visible stars, and I could not identify which stars I was able to see.	crescent moon, waxing - I liked seeing the moon after two days of cloudy nights.
46	felt kind of special because I was with a friend and she pointed it out as her favorite constellation.	orion's belt,
47	Though I was unable to identify as many constellations as the previous viewing, this was still fun and relaxing for me. It is just really peaceful looking at the night sky.	Orion's belt, betelgeuse, bellatrix (I am fairly certain).
48	I continued to ponder the impact of this environment.	Yet again light pollution worked against this. I was able to make out a constellation or too but not much.

49	Once again, I felt satisfied as I was gazing in awe of the bright stars that lay upon the earth. My emotions and stressful moments were set aside from my memory during the 1-hour observation of the bright, shining stars. I did not think much about light pollution in contrast to yesterday's observation since I observed them from an isolated spot which made me feel happier in sighting the stars. This observation inspired me to change my habits at home, such as turning off artificial lights at home and not regularly using my phone at night.	Orion, Gemini and Cancer constellations
50	It made me feel relieved to be out in the dark looking at something other than a screen. It made me feel strange this night as I wondered about how it is that a member of an ape species that walked out of Africa so long ago would be looking up at the sky from another continent trying to assign names derived from a language spoken by the people on yet another continent of an empire that collapsed thousands of years ago.	Canopus, Sirius, Beta Centauri, Alpha Centauri, Crux, Orion's belt
51	This time I went out on my own. I noticed that I felt my head become quieter when I looked at the stars, and thoughts returned when I focused on something else. It was a lot more peaceful to be alone and enjoying the serenity, although I was also alone in the dark so somewhat on edge. I felt disappointed when I could not find Perseus. I hope to find it or wait for the right opportunity to see it in future.	I made an effort to learn some more before coming out for my last session. I learned that Oriens belt has the rest of Orion around it (though upside down). I also saw Canis Major to the right of Orion. I didn't know that Perseus was visible in the southern hemisphere and was pretty excited to try see it when I found out because he is my favourite Greek hero. I watched a youtube video on how to find Perseus but I couldnt spot it, which was dissapointing.

52	it is now worth noting that for this stargazing session i was no longer on kangaroo island, rather in the the Adelaide suburbs where i live. I went outside and looked up however it was far less impressive than the previous 2. visible stars were scarce, and the only constellation i saw was the southern cross. This is far different to what i saw on KI, so it made it clear the damage that light pollution has. Because of this reason during the session i did not feel relaxed, or curious. In fact i felt somewhat disappointed in what i was seeing and got very bored very quickly and went back inside. Unfortunately this session was very different to the other 2, and i do not have much emotion to comment on apart from disappointment.	Southern cross
53	I was more excited this time to spot the constellations, like its a game. The full moon made it more challenging to observe the stars, however added a nice glow to the sky, whilst also taking my mind to dwell on the distance of the moon and what it would be like to orbit/land there. Overall it was a fun experience and almost took me away from being on earth, as though I was in a completely different world.	Puppis, Canis Major, Orion, Sirius, Hyades, Gemini, Crux, Centaurus, Leo, Carina
54	amazed the stars shined bright over our tent in the riverland, i felt insignificant looking up at the bright sky fully lit with a full moon,	i saw the south cross and the pan however i feel there was more i can see however i was unable to identify these.
55	As I was seeing these objects, I felt like I was really learning how to correctly identify the objects. Although I don't know the exact names, I know what to be looking for and can locate them based off of the stars around them. I was also feeling amazed about how big this universe is and how small we are, but I felt at peace as well, knowing that the creator of the universe looks after tiny little me.	•Milky way •Southern Cross •Triangulum Australe •Source pan •b Centauri (pointers to the cross) •Alpha Centauri (pointers to the cross) •Sirius (Brightest star) •Puppis •Big red star •Centaurus

56	Short answer, i felt overwhelmed, long answer i was frustrated that i couldn't see more, and due to already struggling recently with anxiety and overthinking, i was upset i couldnt see more or any shooting stars, i was happy to see what i could but i wanted more, but also there are other factors with seeing stars, like needing to be outside which overstimulated me with sounds and bugs and made me uncomfortable	i could see the brightest star, if i stared really hard i could see a bit of the milky way and i think i saw Ursa Major (i had to look up if i was correct), i saw the usual of flashing stars that looked like satellites of some sort but no shooting stars which was sad
57	I feel sad because I was having dinner in the city and I can't see much compare to the view that I saw on Kangaroo Island where the stars and milky are bright and clear.	Stars (very dim due to the light from the city)

	On this night I was camping at Centennial Campground at Mount Crawford in South Australia. I felt happy to see the stars, because it was the clearest Milky Way I had seen all year. I could even just make out the Dark Emu. I could see Sirius shining out from Canis Major, and I could see Canopus too, but I couldn't figure out the constellation of Carina, even though I knew it was there. I could clearly see Orion setting and Crux rising, and make out Fornax over the pine forest in front of Mount Crawford. At about 9pm I noticed Scorpio rising (and then some clouds came over at about 9.15pm). I was happy to see the clear bright sky, near to the sacred birthing trees down by the Para River. I imagined all of the women, generations and generations of women, who had laboured and birthed under the same stars, for thousands and thousands of years. I felt a strong connection to those women who had come before, and to their experience of birth, and to the women of the future, like my own daughter, who might one day birth her own children. It reminded me that although I was working out in the field, and looking at these stars and constellations, I would soon be going home, and seeing my loved ones, even though the stars are not as bright where we live. I could see the brightness on the horizon, probably the lights of a town or of the city of Adelaide, and I couldn't see as many stars on that horizon, which made me feel sad. Even in that special place, the light of the present was affecting the light of the past and maybe even encroaching on the future - would my daughter and	
58	her daughters and their daughters be able to see the stars?	Milky Way, Sirius, Canis Major, Canopus, Orion, Crux, Scorpio, shooting stars, satellites, Dark Emu
59	crazy how the universe works and how big it is.	southern cross, orions belt, moon and other stars
60	in awe, mesmerized, at peace, longer you look the more you see	aircraft, stars in clusters
61	Un-phased this evening. Although very tired anyway	Orion and Alphard were the only new ones tonight. Slight cloud cover meant there was less to see

62	I felt calm, I was doing some mindfulness watching the stars and I was very relaxed. I had had a busy week and it felt good to stop and slow down and look at the stars to try and relax a bit.	scorpius, southern cross, Jupiter, Venus
63	Finding the celestial objects made me relaxed and eased my mind. It was nice to come back to something so peaceful and beautiful every day, it made me appreciate more small interactions in nature that I wouldn't usually pay attention to.	I only saw Orion/the Canoe, the Southern Cross and the Moon.
64	I felt peace and happy also help clear my mind from stress and everything	different constelations such as norma, ara,alpha centauri, omega centauri cluster and the moon
65	The final time was a shorter period of time because I did it by myself I would say approximately 15 minutes , I had just had a busy day at work so it was nice to have some peace and quiet and time to just relax and reflect to myself , while lying on the front lawn I started to take a lot of notice in the sounds around me which include crickets and other small animals / insects ruffling around in the leaf litter . This made me feel slightly anxious as I didn't have any shoes on and was concerned that something might bite my toes which is why I wasn't out there as long as last time , but this than led to me reflecting on the last time I stargazed that yes, I am small but there are still so many things smaller than me who view the world in a completely different way so that made me just sit in silence and let that sink in. It was slightly overcast so I wasn't able to see as many stars but in the gaps, I saw a plane fly over and that made me feel intrigued but slightly jealous because I wished it was me going on an adventure somewhere. As it was overcast I was noticing the different colours in the clouds and the way the light pollution had impacts on the stars closer to the horizon which made me slight sad because I was potentially missing out on observing something beautiful but because there was too much light I could of missed out. Then my cat came to say hello and I decided to call it a night after feeling refreshed and cold and decided to go back inside	stars, plane, milky way

66	As usual it made me feel more connected to nature and more at peace, but it was also a bit disappointing with how there were so many less stars visible than what there were in the last session at home. While it was not quite as clear of a night as the last time I was at Anstey Hill, the light pollution seemed somehow much brighter than the last time I was at this location. Looking at the stars and seeing the constellations which I am able to identify, also gives me the strong desire to learn more constellations and about the stars, and also makes me really strongly want something to be done about light pollution and how it could be potentially enforced. I feel so connected with nature and the universe when I look at the stars, and feel that if more people were able to do this they may as well, and people may be more inclined to care about our earth. It also makes me think that with continual population increases, and more buildings being constructed, light pollution is something which is likely going to only get worse. While it does make me feel happy and at peace looking at the stars and finding the constellations, it also makes me feel frustrated that more is not being done to prevent light pollution.	The Iron pot, Southern Cross, Orion's belt
----	---	--

67	Out of all the observation days this was the least engaging as the light pollution from the location resulted in an underwhelming star gazing experience. It made me miss home as things in the city are so different. I went with a friend to Windy Point which was fun despite the cloud cover we could see a few and both thought the mobile phone app was cool. The technology side takes away from the experience as well helping name 3 constellations with ease. After some research to try find a better location as it was still early in the night, we decided to call it a night as the best place near Adelaide was in Murray Bridge Dark Sky Reserve. As my friend is a photographer, we decided it would be awesome to go there in the coming weeks to do some wide-angle long exposure photos. I've never photographed the sky before so I'm really looking forward to going and seeing what I can captures. I felt less connected in this experience because of the manmade factors as camping is in my opinion the best time to disconnect from reality and technology to look at the stars. It was interesting to compare the different locations on the ability to see the stars and the feelings it enacted. Without the clouds, cars skidding on the road and other people's loud music I think the company is what makes star gazing enjoyable. I was slightly frustrated with the clouds and how dim the stars were but I look forwards to going to photograph the stars in Murray Bridge so there was another positive outcome in the situation.	Using mobile phone app after initial search Cancer constellation- just up from the Northeast horizon cancer was one of the most visible with the cloud cover despite the stars being dim with the city lights. Using Cancer as a midpoint Leo (right side) and Gemini (left side) were spotted adjacent. This is a simple group of stars to recognise especially with binoculars. Leo constellation- located Northeast of the horizon slightly down from Cancer. The neck back and tail star were the brightest. I sued the app to identify this one as the light pollution made it hard top spot all the stars as some were quite dim. Gemini constellation- the cloud kept covering Gemini so I could only see everything but the feet stars. Using the app helped confirm I was in fact seeing this constellation. This was difficult to spot until I googled that finding Orion's Belt which is 3 stars tightly grouped together in a line formation and moving to the right and down helped. I also used Cancer constellation in the process. It was in a Northwest direction very close to the horizon. Orion's belt- tightly grouped line of stars located West on the horizon.
68	Finding the celestial objects made me feel excited, especially seeing a moving object which prompted me to figure out what it was.	Alpha centauri/ Cetaurus, canis major, leo constellation, puppis, Tiangong space station

69	this night was my first night of star gazing, and it took me some time to gather my bearings as I had never properly tried to identify celestial objects before. I found it challenging at first, but once I was able to locate crux it was easier to use a star map as a guide. I was surprised about how lit up the sky was even at 10 pm, and I thought back to the videos I had watched about light pollution. I do feel as though there was a glow across the sky, which was something I hadn't thought much about prior to beginning this task. It did make me feel a little sad/disappointed that there were so many stars that I just wasn't able to see and made me reflect on how much energy must be wasted in this process. There were some stars that were visible on this night, which made me feel a great sense of accomplishment in identifying. I found this first time to be a bit out of my initial comfort zone, but was an overall very enlightening experience.	sirius, crux, hadar, musca,
70	Finding the celestial objects made me feel contrasting ways. I felt curious to continue finding stars, however I also felt frustrated. This frustration was due to both cloudiness and light pollution, which deemed it difficult to identify celestial objects. Eventually, I became fed up as the streetlights near my house made it so difficult for my eyes to adjust and identify objects. I was able to understand how light pollution affects animals such as sea turtles, as it is so powerful, bright and unnecessary.	Miaplacidus, Acrux, Carina, Centaurus, Sirius
71	Tonight felt very relaxing and comforting again.	I thought I saw a shooting star but it was very quick so not too sure. Besides that, it was similar to the previous nights. But I think I could make out the southern cross constellation.