# Economic, Environmental and Community Benefits of Night Environment Conservation in Australia

**AUTHORS**: Marnie Ogg, Gabriella Allegretto, Landon Bannister, Nalayini Brito, Andrew Cool, Theresa Jones, Richard McDermid, Jennifer Martin, Sofia Oliver, Kellie Pendoley, Fred Watson, Ken Wishaw.

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# Executive Summary

Australia is arguably one of the darkest countries in the world. Our continent has thousands of national parks and reserves, world heritage sites and protected areas renowned for their ecological, economic and cultural heritage values, but only three prized as Dark Sky Places (DSPS). Places of natural darkness are threatened by light pollution or excess artificial light at night. This trend is exacerbated by the global shift towards LED technology that focuses on energy and carbon reduction and standards and guidelines that struggle to address the rapid evolution and adoption of their use. This results in an increase of light pollution of up to 6% year on year, making it one of the fastest growing global pollutants.

Removing light from the environment removes the deleterious impacts immediately, however the benefits of light at night (enhanced efficiency, financial growth, social support and perceived safety) make eradication complex. Solutions point towards a consolidated and far-reaching approach that aligns multiple stakeholders (government, industry and community); includes a consolidated implementation of best practice outdoor lighting principles and is supported by binding and enforceable regulations. Countries attempting national actions are doing so with some degrees of success. The French Decree on light pollution around parklands, for example, has advanced technologies and shown a marked decrease in light pollution within just a few years of implementation.

This top-down, government regulated approach to behaviour changing is obvious and proven and when paired with a grassroots movement that develops professional skills, increases community awareness, and encourages local buy-in is shown to have greater success. Critically, efforts need to be sustainable, scalable and able to withstand the tribulations of adapting human behaviours. Public, local council and existing advocate-targeted research underpinning this inaugural report highlight the growing urge to enhance environmental outcomes through dark sky stewardship and the lessons learned from international and domestic dark sky conservation organisations. International groups that are typically small in size, volunteer led and suffer from a lack of skills and funding, demonstrate the need for a locally driven, government-endorsed dark sky network and accreditation scheme that resonates with the Australian audience. Guided by a multi-disciplinary, light pollution council this group of subject matter experts would champion advocacy, lead science-backed conversations and guide regulators and community to ultimately drive down light pollution levels.

With only 20% of the world's population able to see a dark night sky, the opportunity to build economic stimulus and an irrefutable international reputation for the best night skies in the world exists now. This can be achieved by targeting five key areas: advancing outdoor lighting standards; updating and strengthening legal frameworks; collaborating, researching and communicating impacts of artificial light at night on the natural environment; engaging, educating and rewarding industry, community, and government for conservation efforts; and increasing natural areas designated as dark sky places. Whilst the goal of removing light pollution from our night environment may require time, effort, and financial support, the long-term economic, environmental and community benefits to Australia and all its inhabitants are too numerous to simply be lost in light.

# 1. Recommendations

The following recommendations are not in any specific order. They target the reduction of light pollution and increase the value of the night environment. Stakeholders who may be suitable to lead the actions are also tabled below.

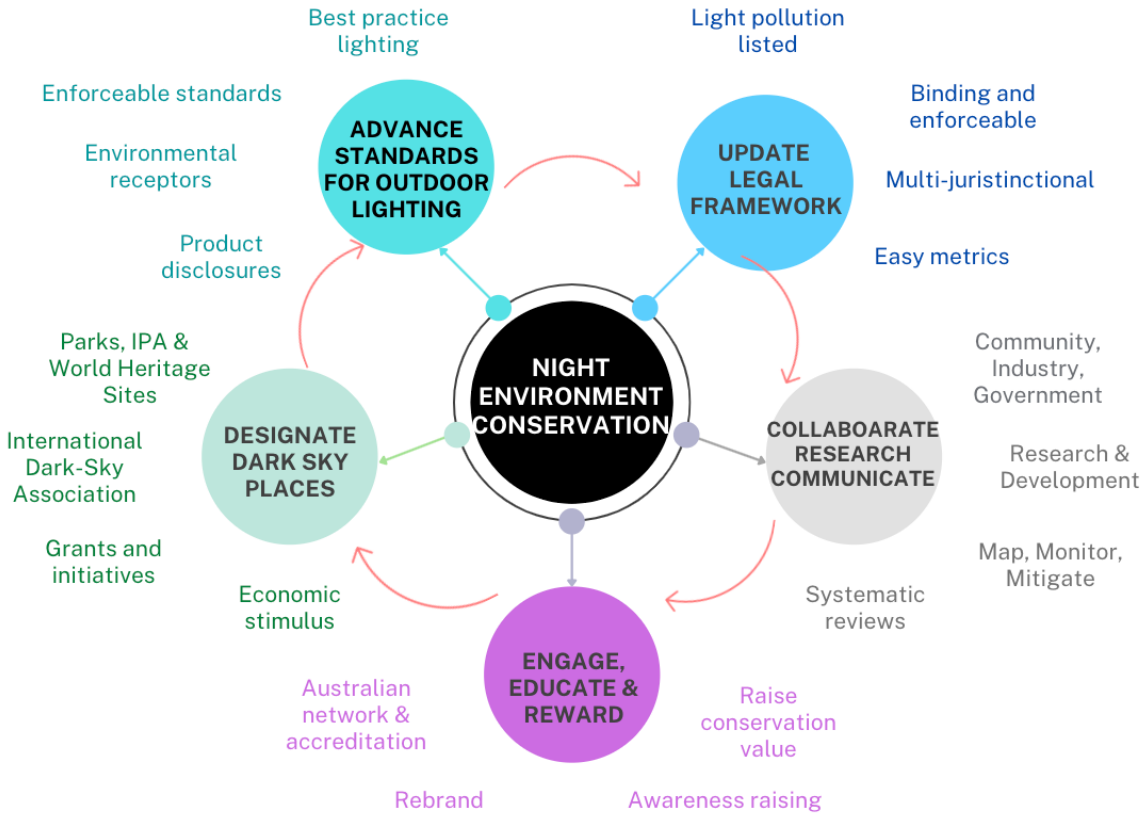



*Figure 1- diagram of recommendations*

## 1.2. Recommendation A: Update Existing Legal Framework and Supporting Mechanisms

*Table 1 - Recommendation to update legal frameworks and supporting mechanisms*

| *The benefits of explicitly listing light as a pollutant will provide clarity and focus on the ecology and human impacts of exposure to ALAN.*<br>*For example, noise is listed as an environmental pollutant with a suite of legislative bodies to address its impacts. Light pollution, like noise, will require a multijurisdictional and situation-based metrics for enforcement* | |
|---|---|
| **How** | **By Whom** |
| List light as a pollutant with jurisdictions through the EPA, Police, Local Councils, Roads and Maritime services. | EPA - state by state |
| Create and adopt easily enforceable metrics | Australian Standards |
| Strengthen the national Planning Policy Framework and add specific reference to the control of obtrusive light. | Australian Standards |
| Expand AS4282 to include environmental receivers rather than just human dwellings | Australian Standards |
| Expand the scope of the planning permission process to introduce regulations for exteriors lighting including advertising and entertainment | Australian Standards |
| Strengthen Statutory Nuisance provisions removing exemptions. Move from influential guidelines to legally binding, retrospective and enforceable policies | Australian Standards |
| Develop a Light pollution council or Steering Group, Guidelines Development Group, Systematic Review Team, and External Review Group and support guide government policy changes. | Light pollution council (to be formed) |

## 1.3. Recommendation B: Advance Australian Standards for Outdoor Lighting

*Table 2 - Recommendation - Advance Australian Standards for Outdoor Lighting*

| *For significantly enhanced Australian environmental outcomes, and reduced light pollution good quality, cheap, night sensitive lighting, best practice standards and easily adopted standards, should be made freely available and accessible to the public, government and industry.* | |
|---|---|
| **How** | **By Whom** |

| | |
|---|---|
| Empower local authorities to enforce ALAN reducing regulations | EPA - state by state |
| Raise awareness of Australian standards by remove copyright and paywall restrictions on access. Set binding and legal limits on the amount of blue light, brightness, directions and density of lighting and colour temperature and times of usage. | Australian Standards |
| Adopt product disclosures and standards for outdoor lighting and legal requirements that all lighting sold and distributed come with instructions of the control of ALAN. (Including green energy sources) This could emulate energy star ratings schemes. Issue penalties for non-compliance. | Department of Industry Science Energy and Resources (DISER), International Association of Lighting Designers (IALD), |
| Adopt Best practice use for lighting. design a national program of best practice categories of light usage in conjunction with community, ecologists, lighting professionals and police. | ADSA Approved existing framework may provide a good base for this. |
| Ensure the relevant standard committees should ensure members comprise a diverse array of representatives, including those with backgrounds in ecology and human health. | Australian Standards |
| An increase in the frequency of reviews and updates would also better enable standards to keep pace with the rapid rate of research and technology advancements. | Australian Standards |

## 1.4. Recommendation C: Educate and Reward Night Environment Conservation Efforts

*Table 3 - Recommendation to Educate and Reward Night Environment Conservation Efforts*

| *An Australian accreditation program will strengthen and unify mechanisms, authorities and community night conservation efforts in Australia. It will provide renewed focus on the currently undervalued night-time environment, increase awareness levels of the impacts of ALAN on ecological and human receptors, update strengthen current policies which continue to permit poor lighting habits.* | |
|---|---|
| **How** | **By whom** |
| Create a light pollution council that monitors light pollution levels in Australia, guides science-backed, policy-forming information to commonwealth and state departments, develops a remit for the control and prevention of ALAN, guides and oversee planning and planning and environmental policies, ensures the calibre of accreditation schemes. | Light pollution council - to be formed |
| Rebrand and educate dark sky conservation to Night Environment conservation or similar, removing negative | DAWE, DISER, ADSA |

| | |
|---|---|
| connotations of the 'dark' and more closely aligning it with enhanced environmental outcomes. | |
| Incentivise dark sky governance and awareness to all levels of government, industry and community through the creation of a Commonwealth Government supported Dark Sky Network and Accreditation scheme bottom up | Light Pollution Council, or the ADSA |
| Emphasise the role of education through the inclusion in school curriculum, lighting industry groups, cultural institutions and NGOs to provide widespread public awareness | Education departments, cultural institutions, NGOs |
| Raise the value of the night environment to justify the time, effort, money and enforcement required to preserve the night environment through education, tourism grants. | Tourism Australia, DAWE, ADSA, ALC |
| Create universally adopted media and education packs for councils, schools for awareness raising, Australian based. | Light Pollution Council, ADSA |

## 1.5. Recommendation D: Collaborate, Research and Communicate

*Table 4 – Recommendation Collaborate, Research and Communicate*

| *Gap identified in this report and understanding of all the impacts of ALAN is required to guide policy changes and drive technological advancements. Australian environment and human-well-being would benefit from additional research on local, endemic species, environment and human health and the impacts of ALAN* | |
|---|---|
| **How** | **By Who** |
| Address, review and refine gaps identified in this report, and understanding of all the impacts of ALAN required to guide systematic ongoing monitoring. | Light Pollution Council |
| Further research, critical data and research gaps that could be addressed in future studies, raise awareness of ALAN, and the effectiveness and willingness to adopt other recommendations made in this paper | ADSA |
| Adopt principles, and seek collaborative avenues with international and domestic dark sky and other conservation efforts that promote a global message and further research and development | Light Pollution Council |
| Seek, develop and produce Australian-based research papers, baseline measurements and development technology | NESP, Urban light Lab, NERAL, Maritime and road services |

| | |
|---|---|
| opportunities that review mapping, monitoring and mitigation/growth of light pollution. | |
| Establish and research links between light pollution and public health, waste, carbon footprint, money saving and effects on large populations in urban environments. | NESP, Urban light Lab, NERAL |

## 1.6. Recommendation E: Actively Designate Dark Sky Places

*Table 5 - Recommendation Actively Designate Dark Sky Places*

| *This document nominates 37 places for their dark sky values, including world heritage status, as ideal candidacy for dark sky designation, but in essence every national park, Indigenous protected area and green space should seek dark sky designation. Some may successfully qualify as World Heritage areas as they can demonstrate outstanding universal value for their night sky heritage.* | |
|---|---|
| **How** | **By Who** |
| Incentivise councils, Commonwealth Parks and places, Indigenous Protected areas, community groups and individuals to create dark sky places within the near future. | Department of Agriculture, Water and Environment, |
| Reduce obstacles to creating dark sky designated areas through the implementation of tax incentives and adoption of new technologies | DISER |
| Strengthen economic stimulus through the Implementation of incentives and grant funding that support mutually beneficial dark sky conservation and astrotourism, cultural awareness | Tourism Australia, Aboriginal Land Council |

# 2. INTRODUCTION

The publication of the National Light Pollution Guidelines for Wildlife in 2020 set a national benchmark for the recognition of Artificial Light at Night (ALAN) as an environmental issue requiring management. While these guidelines focussed on wildlife, the Department of Agriculture, Water and the Environment recognises that there is also a spatial element to both managing light in light-polluted areas and conserving dark skies in areas that are still naturally dark. The Australasian Dark Sky Alliance (ADSA) investigated the most appropriate mechanisms to conserve, and potentially protect, dark skies in Australia and to assess whether a network devoted to dark sky site identification, maintenance and knowledge sharing across Australia would lead to enhanced environmental outcomes and reduced light pollution.

Specifically, the department has requested that ADSA provide a comprehensive report that:

- summarises whether there is a need for dark sky conservation in Australia (Section 3)
- reviews existing domestic and international accreditation programs, conservation mechanisms and/or other initiatives that are, or could be, utilised to raise awareness and enhance environmental outcomes for dark skies in Australia (for example, but not limited to: IDA accreditation; the Australian National Reserve System; UNESCO World Heritage places; UNESCO biosphere reserves; and local government planning schemes) and, where protected places do not currently consider light pollution or how management of artificial light could be incorporated into place-based protection mechanisms (Section 4).
- explores whether IDA accreditation is the most appropriate tool for enhancing conservation outcomes in relation to dark sky places in Australia (Section 5)
- identifies opportunities for new accreditation programs, conservation mechanisms and/or other initiatives to enhance environmental outcomes through dark sky conservation, including a national dark sky network (Section 6)
- identifies geographic locations* that would be a high priority for dark sky conservation based on, but not necessarily limited to: their ecological value, land tenure, presence of a dark sky champion or advocate and likelihood of meeting IDA (or other dark sky program) accreditation requirements (Section 6)

  **High priority geographic locations can be both areas that are, and should remain, naturally dark and areas that are already exposed to light pollution but are engaged in or have aspiration to engage in light management activities. It is important to address both types of areas in the report.*
- considers the feasibility of a dark sky network, how such a network might function and what it could achieve (Section 6)
- identifies relevant dark sky network stakeholders** and the best way to engage with them (Section 6)

  *** A relevant stakeholder to a national dark sky network would have land rights and/or responsibility over a geographic area that is likely to meet one of the eligibility requirements of the IDA's Dark Sky Place designations (or similar accreditation). A relevant stakeholder would also have aspirations to manage artificial light to achieve dark sky objectives, an ability to work with partners across their region to develop light management plans, and capacity to engage more broadly with stakeholders from other regions working to achieve dark sky conservation goals (i.e., participate in a national dark sky network).*

These objectives are addressed in the following sections.

# 3. Need for Dark Sky Conservation in Australia

## 3.2. Background

This report was developed by the Australasian Dark Sky Alliance (ADSA) a not-for-profit organisation, currently leading in educating the public, decision and policymakers and industry on the impacts of artificial light at night. ADSA's Board of Directors represents a wide-ranging group of subject-matter experts (SMEs) that parallels the diversity of the topic itself: industry, ecology, technology, astronomy, education, science, business, and human health. With first-hand understanding of the National Guidelines; a strong understanding of worldwide regulations, legislation and standards; and dedication to night conservation. The collaborative and comprehensive approach to this document provides sound recommendations to conserve dark sky places and to investigate the feasibility of a Dark sky network in Australia.

The information on the public, local government and dark sky regulations, initiatives and incentives discussed in this paper were obtained directly from a wide range of stakeholders, including dark sky advocates, council environmental officers, representatives of the Astronomical Society of Australia, International Association of Lighting Designers, Landcare, National Reserves Policy and Planning, The International Dark Sky Association Australian Chapters, Lindsay Taylor Lawyers, Siding Spring Observatory Dark Sky Committee, Sydney Coastal Councils, Destination NSW, Department of Industry Science, Energy and Resources (Astronomer at Large). In addition, over 650 responses were received from three audience-targeted online surveys (Appendix A) on their awareness of dark sky conservation efforts in Australia, including the National Light Pollution Guidelines, and Dark Sky Place-making. Participants in the survey were drawn from the Australasian Dark Sky Alliance 2019 Guinness World Record, Globe at Night event participant database (+12500), Australian based International Dark sky Association (IDA) members, ADSA members (+300) and existing IDA Place stakeholders. These parties' responses reflect and represent a percentage of the population with dark sky conservation efforts, actively or passively adopting the principles through involvement with dark sky designated places. In contrast, the Australian Local Council Association (537) feedback demonstrated a low-level awareness of dark sky activities and mechanisms to mitigate ALAN.

### 3.2.1. Light and Light Pollution

All living things on Earth have evolved to respond to the daily cycle of light and dark, with sunlight and moonlight providing constant sources of light for more than a billion years. However, in the past 200 years, following the advent of the electric lightbulb, these natural cycles of darkness and light have been disrupted by the presence of artificial light at night (ALAN).

In Australia, artificial light at night is an important and inevitable component of modern life, enabling longer periods of activity, productivity, recreation, entertainment while allowing navigation and orientation at night. However, evidence is growing that night-time illumination of our streets, homes, sports grounds, commercial and industrial properties is impacting on a range of natural and cultural values including; flora (growth rates, growing season, pollination by insects), fauna (physiology, behaviour, navigation), human health (medical, physiology and

behaviour), astronomy (First Nations, professional and amateur), heritage (western and First Nations) and cultural (oral histories and navigation).

Any light that is not a product of the natural world is potentially problematic, however given humans reliance on light at night, a compromise to this more extreme view is that light in the wrong place, at the wrong time, at inappropriate intensity and colour can be defined as a pollutant. In this context, Light pollution may include.

- sky-glow (increased sky brightness caused by upward-pointing light sources),
- glare (contrasts between bright and dark areas),
- over-illumination (unnecessary number of light sources)
- light clutter (unnecessary number and poorly aimed light sources), and
- light trespass (unwanted light).

Poorly managed light can be observed over a hundred kilometres away (Figure 1). In the past ten years there has been a global movement to transition from traditional gas emission sources (fluorescent, mercury vapour, high pressure sodium) to Light Emitting Diode (LED) lighting technology. Coupled with a movement towards renewable energy sources, the carbon footprint associated with wasted light has been replaced, by 'green' but still light polluting sources. Evidence indicates that the expected decrease in energy consumption that justified the switch to LEDs and renewable energy, has been undermined by an increase in the number and lumen output (intensity) of the LEDS and an associated increase in the proportion of short wavelengths in the LEDs (Kyba 2017).

*Figure 2 - Light glow of Sydney taken From Siding Spring Observatory 350km away (Photo: David Malin c/ Siding Spring Observatory)*

The presence of artificial light at night has led to one of the most pervasive forms of environmental change in the Earth's history. Sanchez de Miguel (2021) estimated light emissions increased by 49% globally between 1992 and 2017.

## 3.3. Dark Sky Values and Receptors

The natural night sky has long been considered the aspect most worthy, or at least associated with dark sky conservation efforts.

### 3.3.1. Cultural Heritage

The study and appreciation of the dark sky is universal in human existence; Greek, Egyptian, Middle Eastern cultures are notable for the value astronomy and astrology played in developing scientific and mathematical concepts and an understanding of the natural world. The influence of stars and the dark sky on humans is universal across global cultures, in both written and oral histories and well recognised for the ability to inspire science, religion, philosophy, art and literature. In Australian First Nation cultures, the positioning of stars and dark patches in the sky provided information used to map the landscape, safely navigate long journeys, predict availability of food and seasonal changes in flora and fauna (Norris, 2016; Norris and Harney 2014; Fuller et al 2014; Hamacher et al 2012).

### 3.3.2. Scientific (astronomical and ecological)

The astronomical value of the dark sky has been recognised for centuries. Its presence has facilitated navigation around the globe and space exploration and assisted our understanding of the expanding universe. Australia is home to one of the most globally recognised observatories, Siding Spring Observatory, which is home to Australia's national optical telescopes, and Australia's first Dark Sky Place. This multi-million-dollar facility has remained dark and scientifically viable through the implementation of the Dark Sky Planning Guideline
The ecological value of preserving naturally dark skies is recognised globally and, most recently, in Australia through the 2020 Commonwealth Department of Agriculture, Water and the Environment's National Light Pollution Guidelines for Wildlife. These guidelines provide an adaptive management framework for mitigating light pollution for the benefit of wildlife and, more broadly, raise awareness of the ecological impact of light pollution for all living species, including behaviour, reproduction, foraging, orientation, pollination, growth and interactions (Gaston et al, 2021; Knope et al 2017; Bennie et al 2016; Owens and Lewis 2018; Navara and Nelson, 2007; Gaston et al 2017; Sanders et al 2018, 2021; Jagerbrand and Bouroussis, 2021). These have been endorsed by the *Convention on the Conservation of Migratory Species of Wild Animals*, an international convention to which 133 nation states were party.

### 3.3.3. Human Health (physiology and psychology)

Humans, like all living things, evolved under the rhythms of the natural light-dark cycle of day and night. Exposure to light at night has been linked to an increased risk of breast and other cancers (Stevens et al, 1992; Hansen 2001) as well as sleep disorders, obesity, depression, diabetes and heart disease (Davis and Smyth, 2018; Cho et al 2021; Svechkina eta al 2020; Aulsebrook et al 2018; Ouyand et al 2018). In 2016, The American Medical Association adopted guidelines to reduce harm from high intensive lighting, establishing links between the lack of natural darkness and public health, especially on large populations in urban environments.

### 3.3.4. Economic (direct and socio-economic)

As the levels of light pollution in North American, Asia and Europe grows the tourism opportunities for the relatively darker places across Australia is predicted to grow (Figure 2)

Since its designation as a Dark Sky Place in 2012, Mount John Aoraki MacKenzie in New Zealand has lifted visitation to over 900,000 people (2019) each year with an estimated value of +$225m per annum and an increase of 250% from its inception. (Figure Appendix 7.2.2) Dark sky tourism initiatives such as Destination NSW Wales Outback Country Dark Sky Strategy, the Western Australian Night Tourism Position Statement and, internationally, Park after Dark provide travellers new and unique experiences delivering economic and job stimulus in regional and rural communities. In 2019, Tourism Australia acknowledged $126 billion was spent on general overnight tourism alone.

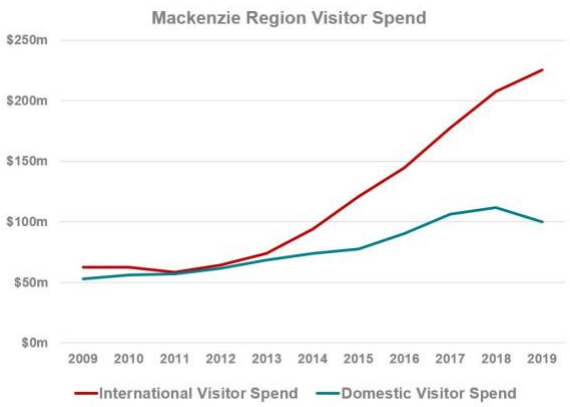
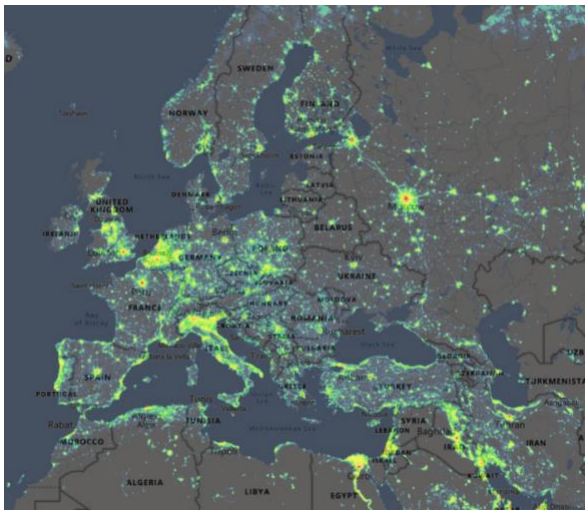



*Figure 3 Visitor expenditure Mount John, Aoraki MacKenzie NZ*

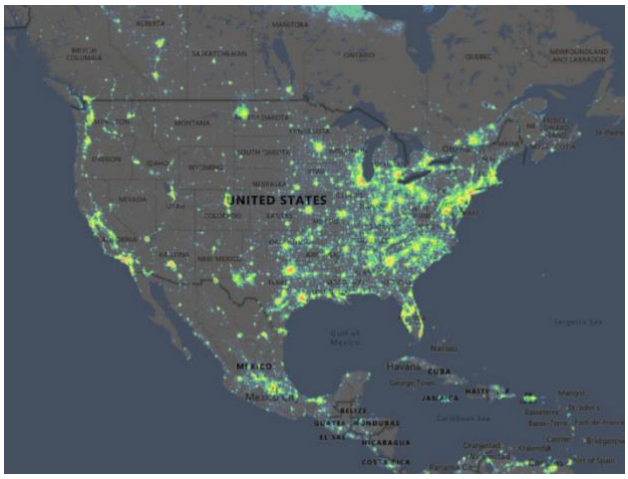




*Figure 4 VIIRs maps, 2021, a) Australia and New Zealand, b) Europe, c) USA. Note the colours representing light emissions scale (not geographic) is the same in all three maps*

## 3.4. International Dark Sky Conservation Efforts

The international agreements and regulations from around the world that provide a framework for management of ALAN and for dark sky conservation have been reviewed (Appendix B) and are summarised here in Table 6.

*Table 6 - Assessment of dark sky conservation mechanisms, benefits to the Australian model and challenges to the implementation in the Australian context*

| Mechanism | Overview | Strengths | Why this would work in Australia | Why this would not work in Australia |
|---|---|---|---|---|
| French Decree Section 10.2.1 | National legislation that restricts upward light spill and intensity and mandates CCT of ≤ 2400K near observatories and recreational parks. | Has driven technology changes Initiated and driven by the people Reduced light pollution by ~6% | The focus in and around National Parks and historic areas of significance provides significant volume of area to be created as dark sky sensitive | Complexity of Federal and State governance of parks and places, would not permit a single, overarching policy to be put in place |
| United Kingdom All-Party Parliamentary Group for Dark Skies Section 10.2.2 | Ten Dark Sky Policies for the Government including strategies for legal enforcement, education, dark sky place making | Has upper and lower house representation. Makes recommendations to parliament | Australian and United Kingdom Governance and policy making, cultural, community and collective mindset comparable | NA *This approach should be adopted in Australia* |
| IUCN World Congress Motion Section 10.2.3 | Motion to educate the harmful impacts of light pollution, the benefits of preserving natural darkness, and methods to reduce light pollution | Supported by the UN and Endorsed by Australia | Supported by Australian Federal Government | Relatively unknown to the broader public in Australia.<br><br>Appeal more to northern hemisphere<br><br>Non-binding international agreement |
| World Heritage Listing Section 10.2.4 | Listing of places of significant scientific value focusing on the sky as the "common and universal heritage" | Has strong global branding and public awareness. Attractive to government support | May only be viable as a dark sky conservation effort for space and astronomically related areas such as Mount Stromlo, Siding Spring Observatory, | Can be time consuming and labour intensive.<br><br>This has not yet been tested in Australia. |

| | | | | |
|---|---|---|---|---|
| | | | Honeysuckle Creek, SKA Murchison<br><br>WHL application documents format should be emulated with DSP making | |
| International Astronomical union<br>Section 10.2.5 | The United Nations Office for Outer Space Affairs (UNOOSA), focuses on the urban illumination or artificial light at night; optical trails of satellites in low Earth orbits | Public awareness is being raised by the impact of Starlink network on the dark sky | Australia has a long and dedicated history of cutting-edge astronomical research and development, and a commonwealth department currently investigating and guiding the outcomes through membership of COPUOS. | May be perceived as an issue that impacts privilege astronomical communities only, not broad in its universal appeal and can be seen to put developing nations needs behind science. |
| United Nations Sustainability Development Goals<br>Section 10.2.6 | 17 goals to reduce carbon footprint, create equality and drive sustainability globally. | Supported by the UN and is well-established | Goals are worthy, but only 3 relating to light pollution. | Relatively unknown in Australia,<br>Tendency to appeal to northern hemisphere.<br>Not commonly recognised by Australian audiences |
| Blue Light Aotearoa<br>section 10.2.7 | Thorough science-based document on the impacts of blue light on the environment, including human health | Widely cited. | Australian environment and human-well-being would benefit from additional research on local, endemic species, environment and human health and the impacts of ALAN | NA<br>*This approach should be adopted in Australia* |
| Croatia Light pollution protection Act 2019<br>Section 10.2.8 | National law enforcing best practices, colour temperature direction prohibit light on water | Is binding retrospective, and enforced nationwide | The inclusion of restrictions over water will benefit Australian National Maritime Parks | NA<br>*This approach should be adopted in Australia* |

## 3.5. Mechanisms for Controlling Light at Night in Australia

Currently, Australia has the Australian lighting standards (see 3.5.3 below), the National Light Pollution Guidelines (see 3.5.1) NSW Dark Sky Planning Guideline (see 3.5.4) and local government initiatives (see 3.5.6). There is no national or state-wide body that coordinates guidelines, policies or strategies and there is no known enforcement strategy to provide a top-down focus on the abatement. As a consequence, there is limited opportunity by industry, government or community to monitor their success or increase the area they encompass. Policy makers know that effective regulations blend hard laws, guidance, education and enforcement and should be simple to understand and enforce. The implementation of regulations and authoritative body(ies), in conjunction with simple and consistent metrics such as curfews, direction, light quality, intensity and colour temperature, could significantly improve outcomes for the environment at night.

### 3.5.1. National Light Pollution Guidelines for Wildlife

While light pollution is not explicitly identified at a pollutant under any state or federal regulations it could be assessed as a potential impact to Matters of National Environmental Significance (MNES), including listed threatened and migratory species or communities or World Heritage sites, under the Environment Protection and Biodiversity Conservation Act (1999) (EPBC Act). In recognition of the potential impact of ALAN on listed species protected under the EPBC Act, the commonwealth government released the National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth, 2020). Developed with the Western Australian Department of Biodiversity, Conservation and Attractions in collaboration with the National Environmental Science Program and Northwest Shelf Flatback Turtle Conservation Program, the guidelines provide an adaptive management framework for managing light pollution for the benefit of wildlife and more broadly raise awareness of the ecological impact of light pollution for all living species. In February 2020, they were endorsed by the Convention on the Conservation of Migratory Species of Wild Animals during their 13th Conference of Parties. Whilst this is internationally recognised as one of the more effective guides to reduce light pollution, it is non-binding and does not require retrospective interventions. As a consequence, it has not been fully embraced by the Australian lighting industry due to a lack of specific metrics and target data for lighting requirements, nor has it been widely recognised by councils as part of their lighting planning processes.

### 3.5.2. State and Territory Regulations

State and Territory legislation and policy frameworks have some provisions for managing threats, such as light pollution, to listed species, but there is a lack of consistency. For example, the Australian Capital Territory Environment Protection Act 1997 recognises artificial light at night as a form of pollution and regulates accordingly for impacts on humans and the environment. Local and regional government requirements may also have specific requirements with respect to artificial light and wildlife. For example, the Queensland Government Sea Turtle Sensitive Area Code provides for local governments to identify sea turtle sensitive areas within local government planning schemes. Development in these areas need to avoid adverse effects to sea turtles from artificial lighting.

In practice, the publication of the National Light Pollution Guidelines has provided a framework for state, territory and local governments to assess if ALAN is a risk for any sensitive wildlife exposed to light sources and to manage the impact. Increasingly, commercial and industrial development across Australia must undergo regulator assessment and approval and are required at State and Federal level, to show how a specific project is consistent with the National Light Pollution Guidelines. The Guidelines are also being used broadly to include the assessment and management of impact on sensitive receptors such as humans, astronomical observatories and all wildlife regardless of their listing status.

### 3.5.3. Australian Standards

In the absence of specific or explicit state, territory or federal conservation mechanisms for regulating the impacts of light pollution, Australian standards are frequently employed by Local councils to manage local urban lighting.

The key Australian standards relating to artificial outdoor lighting are:

- *Australian Standards AS/NZS4282 - Control of the Obtrusive Effects of Outdoor Lighting;*
- *Australian Standards AS/NZS 1158.1 Road Lighting, Vehicular Traffic (Category V) Lighting;* and
- *Australian Standards AS/NZS 1158.3* - Lighting for Roads and Public Spaces, Pedestrian Area (Category P) Lighting.

AS1158 standards are primarily written around the safe movement of both human and vehicular traffic, focussing on the human visual system. Compliance to the standards is based on exceeding minimum light technical parameters (LTPs) and sets no limits to maximum illumination levels. Over-lit areas can inhibit safety by reducing the ability to assess hazards (glare) resulting in diminished response time. In terms of mitigating the ecological impact of light at night, limits are placed on glare and upward waste light, with spill light referring to AS/NZS4282, though only in certain instances and only to human dwellings, not environmental receivers. These standards mention the impact of lighting on wildlife but offer no practical means to address them.

AS/NZS4282 specifically addresses the effects of obtrusive lighting on astronomical observation along with other human vision related issues, such as glare and nuisance. However, the impacts of external lighting on biota are not specifically addressed as one of the potential effects of obtrusive light, instead appearing as an informative appendix only. Again, LTPs are applied as the basis for conformance, set as maximum limits. Applicable LTPs are determined by zones, which include the provision for Intrinsically Dark (A0 Zone) and Dark (A1 Zone) areas where LTPs are the most stringent.

In general, the AZ/NZ standards have limited public awareness and are copyrighted and licensed, meaning they must be purchased to gain access. They are not updated regularly sufficiently often to cope with the rapidity of technological advancements, the fast pace of research, and the rapid rate of adoption of devices such as illuminated billboards and media screens, often mean the market is moving more rapidly than the standards can keep pace with. Finally, and perhaps most critically, they have no regulatory role, unless they are explicitly

conditioned for in a regulatory approvals process and are primarily informative ('should') rather than normative ('shall') standards, making enforcement of any meaningful protective measures difficult.

### 3.5.4. Dark Sky Planning Guideline (NSW Department of Planning & Environment, 2016)

The most significant state-level light pollution planning control mechanism is 2016 the NSW Department of Planning and Environment's Dark Sky Planning Guideline, released to protect Australia's most important visible-light observatory at Siding Spring near Coonabarabran (NSW). The unique guideline preserves the night sky and accompanying astronomic scientific research conducted at Siding Spring facilitating sustained use of the telescopes in an era when many other observatories have been discontinued due to the impact of light pollution.

The formal guideline is the product of a collaboration between the NSW Department of Environment, Siding Spring Observatory and council members of four local areas (Warrumbungle, Coonamble, Gilgandra and Dubbo). The guideline has been adapted due to shifting parameters (technology changes, SEP planning variations etc) but sets out planning controls for developments within 100km of the observatory, imposing mandatory light pollution considerations and prohibition of certain developments if they cannot prove compliance.

State-significant developments within 200km of Siding Spring Observatory must seek approval from the Director of Siding Spring Observatory and the Siding Spring Dark Sky Committee. The four councils within the 100km radius, face obstacles with ongoing non-compliance post construction or with organisational standards that mandate conflicting lighting requirements. Most notably, TAFE installed outdoor lights in the Coonabarabran campus, that were non-compliant with the guidelines, but standard practice for TAFE NSW buildings. These were subsequently retrofitted with consent of TAFE.

In practice the local community of Coonabarabran, the region most affected by the guidelines, has adopted the principles following frequent face-to-face communication between industry and the Siding Spring Observatory Director; education programs such as the state-wide Dark Sky School Education Program; and the economic and emotional stimulus from StarFest, the IDA Dark Sky Park Designation (2016), and Light Pollution Conference (2018).

### 3.5.5. Listed Dark Sky Areas (Astronomical Society of Australia)

The Astronomical Society of Australia (ASA) has a list of designated private or public observatories, professional institutions, and scientifically significant spaces. It partitions these into three categories: research, education, and community use. Such designations are only recognised by the ASA and may provide increased protection from light pollution (by association) but this is not legally enforceable. Whilst the designated observatories are recognised under AS4282 and require a lower threshold for light parameters in lighting design, in practice protections afforded by the listing are not retrospective and have provided little benefit for observatories from the impacts of light pollution.

### 3.5.6. Local Government and National Capital Authority Approaches

A series of local government areas are implementing dark sky principles into their lighting management strategies (see below) or have created policy that assists with mitigating the impact of light pollution. Whilst these actions are noteworthy, they remain limited in their coverage.

Examples of local government strategies are summarised below:

*New South Wales*

- Northern Beaches Council resolved to proceed with an application for an Urban Dark sky Place at Palm Beach Headland.
- Lane Cove Council resolved to develop a recommendation for 'appropriate planning instruments' to reduce the impact of light "spill" on urban bushland.
- Waverley Council resolved to consider incorporate dark sky principles and strategies in an updated Creative Lighting Strategy and consider a Dark Sky Reserve in its parks and along the coast.
- The Blue Mountains Council resolved to support Dark Skies accreditation for the Linden Observatory and wrote to the NSW State Environment Minister urging them to seek accreditation for a Dark Sky Park over the Blue Mountains National Park or Greater Blue Mountains World Heritage Area.

*Western Australia*

- Town of Port Hedland, seasonal restrictions on night street and beach park lighting during the turtle nesting season, October – March each year.
- The WA EPA Environmental Assessment Guidelines No 5, Environmental Assessment Guidelines for Protecting Marine Turtles from Light, released in November 2010 (EPAG No 5). This document is used to provide advice to proponents, consultants and the public generally about specific procedures, methodologies and the minimum requirements for environmental management which the EPA would expect to be met by proposals or schemes it considers during the environmental impact assessment (EIA) process with respect to marine turtles and light.
- State government has adopted a Position Statement that aims to protect local dark and dark sky locations, particularly suitable for tourism, through limiting light and dust pollution.

*South Australia*

- A Light Management Policy and was adopted by the Mid Murray Council in May 2018 that ensures already naturally dark sky in the scoped area is not only protected, but also further enhanced through various approaches including lighting education programs, reducing the number of lights and modifications to existing outdoor light fittings.

*Queensland*

- Sunshine Coast Council Urban Public Lighting Master Plan (2016); developed as part of the Public Lighting Project and aims to deliver substantial improvements to the public lighting network by upgrading streetlights to energy efficient technology. The

plan recognises light management to reduce sky glow (Urban-Public-Lighting-Master-Plan).

- Sunshine Coast Council, all Development Approvals for new projects on or within 2-3 blocks of the beach must address light management conditions specifically targeted at reducing the visibility of light from marine turtle nesting beaches.
- Queensland Department of State Development, Manufacturing, Infrastructure and Planning, Sea Turtle Sensitive Area Code, A Model for Local Government (2019); provides for turtle sensitive areas within local government planning schemes which address light management within 2km of important turtle nesting beaches. The purpose of the code is to ensure that development does not create harm to sea turtle nesting and sea turtle activity by avoiding adverse impacts generated from artificial lighting.

*Tasmania*

- TasPorts Environmental Standard - Light Pollution; the Light Pollution Standard The purpose of this Environmental standard is to define the minimum standard accepted by the Tasmanian Ports Corporation Pty Ltd (TasPorts) to ensure that artificial lighting does not cause environmental harm or environmental nuisance from TasPorts' owned, operated or managed land and/or berths and water ("TasPorts facilities") which includes lighting on vessels using TasPorts' facilities.

*Australian Capital Territory*

- The National Capital Authority: Outdoor Lighting Plan, Outdoor Lighting Policy. The Outdoor Lighting Policy has been prepared to guide the range of considerations necessary when installing or renewing outdoor lighting in the nationally significant areas of the Australian Capital Territory. It seeks to ensure that the planning, design and operation of lighting balances the needs of people and the environment. Importantly, the policy strengthens the role that lighting plays in our understanding and appreciation of the National Capital and Canberra's urban landscape.

*Victoria*

- The State of the Marine and Coastal Environment 2021 Report for Phillip Island Nature Park included indicators for light pollution, contaminated land and air quality, which have been updated in the 2021 report to include a coastal focus. This is part of a series of Victorian state of environment reports in the 2020–24 reporting cycle. Significantly, the nature park has worked in conjunction with Bass Coast Shire Council, Regional Roads Victoria, SP Ausnet and the local community to turn lights off for 10 nights during the great migration of shearwaters each year.

### 3.5.7. Overview of Australian Light Pollution Mitigation Mechanisms

Whilst the existing light pollution mitigation mechanisms are significantly reducing the effect of ALAN, they are largely isolated and thus, while effective at the local level, they are not at the scale to adequately protect the majority of Australia; they are limitations in several ways (see Table 7) and as outlined above they are non-enforceable and non-retrospective. Local council members, urban planners, and policy makers state they would be more inclined to

consider night conservation efforts, if: the cost of good quality outdoor lights was reduced; they had more time to prepare an application for the IDA or similar; there was more Australian-based information available for outreach purposes, and significantly, if there was more regulatory support. If commonwealth legislation could not be enacted, light pollution, like noise could be mitigated through a multi-jurisdictional approach (Appendix E) and by elevating their status, strength and audience awareness through a dark sky network and accreditation scheme.

*Table 7: Australian mechanisms to reduce light pollution*

| Mechanism | Strengths | Limitations | Recommendation |
|---|---|---|---|
| National Light Pollution Guidelines for Wildlife Section 3.5.1 | Widely used by state and territory, and commonwealth regulators as part of the environment impact assessment process<br><br>Increasingly being used by councils.<br><br>Require all new developments to show how the project is "consistent with the guidelines". | Limited in audience awareness at council and general public level.<br><br>Lighting industry desire for metrics. | Include easily adopted metrics<br><br>Create body that can enforce standards.<br><br>Increase local government and general public awareness. |
| State and Territory regs and guidelines Section 3.5.2 | Operate in isolation and on a local level. | Ad hoc and not holistic.<br>May be singular in focus – ie species (marine turtles) or human focussed. | Create light pollution council to help steer policy guidelines, unite isolated voices, dark sky planning policies and procedures, and inform public, industry and government of next steps. |

| | | | |
|---|---|---|---|
| Australian standards 1158 and 4282<br><br>Section 3.5.3 | The most frequently cited.<br>AS4282 recognises environmental values<br>Can be challenged in court under the Tort of Nuisance | Do not have provisions for environmental receivers.<br><br>Do not set upper limits on light emissions.<br><br>Are not retrospective.<br><br>Are not readily available to or understand by the public, are copywritten and behind a paywall.<br><br>Are formative not normative.<br><br>Has had limited success or use in court challenges.<br><br>Technology advances quicker than the standards. | Strengthen awareness of guidelines by: removing the copyright and paywall.<br><br>Adapt standards to normative and include environmental receptors<br><br>Achieved through the creation of enforcement agencies and strategies.<br><br>Extend members of the standards committee to have more diverse skillsets and include human and ecological focus. |
| NSW Dark Sky Planning Guideline Section 3.5.4 | Is supported and enhances economic viability to regional areas.<br><br>Strong representation from 4 councils and Siding Spring Observatory dark sky committee.<br><br>Increased community buy in, particularly since the dark sky park has gathered momentum and | Is effective within a 200km radius of the observatory only and most substantially within an 18km radius. | Incorporate the successful attributes of this document in future planning documents. |

| | | | |
|---|---|---|---|
| | funding for festivals and events | | |
| Listed Dark Sky Areas (Astronomical Society of Australia) Section 3.5 .5 | The Dark Sky Planning Guidelines were based on aspects of this agreement. | Is limited in number and to public, educational or scientific astronomical observatories only.<br><br>Is not retrospective or normative.<br><br>Light pollution advocacy from astronomical societies may be weak, or in contrast, evangelistic. | Designate observatories as Dark Sky Places – this could be achieved through IDA designation, the creation of an Australian Dark Sky Network or, in the instance of Mount Stromlo, Honeysuckle Creek, Parkes Dish, Siding Spring Observatory, may include World Heritage Status for the dark sky values. |
| Local Government Approaches Section 3.5.6 | Incorporates support from local members, constituents and stakeholders.<br><br>Is increasingly evolving within isolated communities | Operate in isolation from one council/state to another.<br><br>Is not supported by commonwealth or state policy, grant funding or incentives.<br><br>Is usually begun by individuals interested in dark sky designation, and support through councillors. | Incorporate the successful attributes of these approaches in future planning documents and with state and commonwealth strategies. |

## 3.6. Adopting Noise Pollution Approaches

While initially onerous, the most effective means to reduce light pollution is through legislation as demonstrated by the acceptance of nation-wide light pollution reducing policies, in Europe.

In Australia, noise pollution is a nationally recognised, regulated pollutant that is enforced by many authorities on a state-by-state basis and subject to source type. Licensed industrial premises, neighbourhood areas, vehicles and transport sources are regulated by the environmental protection authority, local councils, police, roads and safety respectively with

differing, enforceable metrics that reflect the type of environment, time of day, volume or intensity. These approach, outlined in (appendix E) represent a working existing model that could be endorsed to regulate light pollution, nationally.

*Table 8: The comparison of noise and light pollutions, instruments to support legal enforcement of regulation*

| Instruments for support of legal enforcement | Noise | Light |
|---|---|---|
| Listed as a pollutant. | Yes | No |
| Has publicly available documentation on regulations, methods to reduce impacts or report issues. | Yes | No |
| Has relevant and recognised metrics to advise harmful levels. | Yes | No |
| Has strong, enforceable and retrospective regulations. | Yes | No |
| Public, policy makers and commercial operators have knowledge of and easy access to policy and control mechanisms. | Yes | No |
| Is often resultant of poor planning or policy making. | Yes | Yes |
| Requires multi-jurisdictional monitoring and enforcement. | Yes | Yes |
| Impacts human health and wellbeing, in home and workplace settings. | Yes | Yes |
| Is known to have detrimental impacts on flora and fauna. | Yes | Yes |
| Impacts can be readily mitigated through behavioural and policy change. | Yes | Yes |
| Alternative less or non-polluting options exist. | Yes | Yes |

# 4. Review of Existing Dark Sky Accreditation Programs

In the absence of nationally directed regulations to protect the dark sky, the calls for reducing light pollution have historically come from amateur and professional astronomy groups who have recognised the impact of increased sky glow on the ability to view stars. The main tool used by these volunteer-supported, and not-for-profit, groups are typically *ad hoc* accreditation programs developed in-house by members, with no legal or statutory authority. A review of the currently operating programs globally is presented in Appendix B and summarised in Table 9 below.

*Table 9: Existing dark sky accreditation programs around the world.*

| | Urban or remote areas | Number | Places in Australia | Focus | Comments and recommendations |
|---|---|---|---|---|---|
| International Dark Sky Association (USA) | Yes | 195 | 3 existing,<br><br>5 in progress | Conservation, outreach and education | Most recognised in Australia within dark sky community. Could be supported by a local agency<br>https://www.darksky.org/ |
| Fundación Starlight (Spain) | Yes | +200 | none | Tourism, conservation, outreach and education. Scalable through training | Best suited for Spanish speaking markets.<br>Outreach and tourism education programs could be co-opted in an Australian network.<br>Offers consultancy<br>https://en.fundacionstarlight.org/ |
| Royal Astronomical Society of Canada (Canada) | Yes | 32 | none | Preservation, outreach and education | Well suited scheme for Australian environment. Programs and criteria for place making could be co-opted in an Australian network.<br>https://rasc.ca/lpa/dark-sky-sites/ |
| Dark Sky Register (Australia) | Remote only | 4 | 4 | Australia | Australian based, but staffing and management skillsets unstated<br>http://www.australiandarkskyregister.com/ |

# 5. Review of IDA Programs in an Australian Context

This section is a review of the IDA accreditation program and its applicability and appropriateness for dark sky conservation in an Australian context. The review has taken into account the results of three online surveys (Appendix A), first-hand experience of ADSA members and board members, feedback from designated dark sky places and subject matter expert consultation.

Globally, the IDA Dark Sky Designated Places accreditation scheme is the largest and most well recognised dark sky accreditation program. The criteria required for accreditation time consuming, to meet and maintain. Nationally, the IDA has certified three places in Australia (Warrumbungle Dark Sky Park (NSW), River Murray Dark Sky Reserve (South Australia) and the Jump Up Dark Sky Sanctuary (Queensland)) and supports IDA chapters in Tasmania and Victoria.

The benefits of adopting the IDA Dark Sky Places programs in Australia include;

- Program is well established and growing
- Global recognition of certified dark sky places
- Growing Australian awareness through designation of dark sky places
- Established criteria for place making

The limitations of implementing the IDA program in Australia are summarised in Table 10.

*Table 10: Summary of IDA strengths and limitations*

| Potential Impediment | Description |
|---|---|
| **Complexity of application** | The process for approval is rigorous and demands robust community and council support. It typically takes 1-3 years but has been known to take up to ten years. Numerous applications lose traction altogether and for a multitude of reasons. When applications do progress, the lack of a standard format and inconsistencies in meeting approval criteria, has led to unnecessarily expensive, cumbersome, and lengthy reports. |
| **Low value of accreditation** | While the IDA program is widely recognised North America, there is little branding awareness of the IDA in Australia. Councils report an inclination to explore national, world or commonwealth heritage listing, or biosphere designations in preference of IDA Dark Sky Designation. |
| **Inability to meet criteria** | This could range from everything from poor lighting, inability to engage council or relevant stakeholders, or insufficiently dark sky attributes. |
| **Inconsistency and limitation of approval criteria** | IDA assessment relies on gathering data using a Sky Quality Meter (SQM) which are often questionable due to improper instrument use. The criteria do not account for horizon glow using photography (as used by Royal Astronomical Society of Canada) which provides a more consistent approach and inter-comparison with other sites. |
| **Cost/time for implementing new lighting** | IDA charges a $350USD application fee and requires a minimum of 67% dark sky compliant lighting in designated areas and 100% compliance within 3 years of designation. Retrofitting non-compliant lighting can be costly and may be reliant on the support by local energy authorities/street light owners who may prefer to adhere to more readily utilised lighting options. Luminaires determined by the IDA's *Fixture Seal of Approval* in many cases are non-compliant Australian fittings. Designators are therefore required to source lights from Australian-based manufacturers or suppliers which may be costly or unique to the area. |
| **Lack of awareness of light pollution and the issues** | Conservation organisations and councils reported that they are ill prepared to educate local communities and stakeholders on dark sky conservation values and had limited, and non-financial, support from IDA to do so. What is available was America-centric and does not relate to Australian audiences. The creation of Australia-based flyers, documentaries or television shows, incentives to adopt good lighting and ongoing education programs will assist. |

| | |
|---|---|
| **Lack of government support or policies** | The current Australian mechanisms and guidelines for reducing ALAN are not strongly enforced or recognised by councils nor have a recognised body policing compliance. This means that communities are forced to address and communicate IDA-specified standards in isolation and without the support of local government policies. |
| **International ownership** | The US/international focus of the IDA may be a deterrent for uptake. Questions arise around a) offshore funding, b) international authority over local regions, and c) IDA's awareness of Australian policies and standards. |
| **Non-Australian based education materials** | Materials available for dark sky education are predominantly US-Centric (IDA produced) or European initiatives. Unfamiliar cities, units or philosophies can disconnect people from the issues or seem irrelevant and removed. |
| **Qualifying areas are limited** | The IDA criteria require that all land accreditation as a DSP must be on incorporated land, ie., must be legally managed by a Council. In Australia this automatically excludes large private landholdings such as stations and Indigenous Protected Areas which poses significant areas for dark sky conservation. |
| **Capacity** | The IDA comprises a staff of less than 10 people with one staff member managing and accessing a growing number of dark sky place applications. The applications area then approved by a volunteer-based board subcommittee which meets quarterly. Applications are frequently delayed due to the sheer burden of work for IDA staff, together with unique country specific questions, language barriers, cultural misunderstandings and miscommunications, time zone differences etc. The system is not scalable and is resulting in long delays in accreditations, particularly in places outside of the USA. |
| **Lack of auditing and confirmation of compliance** | The IDA accreditation requires ongoing auditing and reporting. However, the requirements are vague and ambiguous, and the approach not well defined. There are few key performance indicators or measures for demonstrating that the DSP continues to meet the accreditation criteria, nor betterment of the environment. The IDA has no mechanism in place to confirm ongoing compliance with accreditation status. |
| **Cultural values** | The program does not actively recognise nor account for First Nations cultural values of the dark sky |
| **Nomenclature** | IDA uses the term 'Dark Sky'. In many cultures 'dark' is perceived negatively. Adopting the term night conservation would broaden the audience, who may be conservation minded. |

In summary, the International Dark-Sky Association dark sky places designation scheme is the most recognised program to create dark sky places in Australia. Its international standing and ability to present a global voice on the issues associated with light pollution, is growing both internationally and domestically. However, the complexity, and ambiguity of applications; lack of local agency and primary approach to place making (rather than people developing) limit its accessibility to an Australian audience. The restrictions on non-incorporated land vastly reduce the areas suitable for IDA Dark sky Designation in Australia. With the view of creating a global network, IDA dark sky designations should be incorporated into the future planning tools for dark sky conservation but should not be solely reliant on this approach.

# 6. An Australian Dark Sky Network and Accreditation Program

## 6.2. Overview

Nearly 80% of Australians live in, or close to, metropolitan areas that are affected by light pollution. Such a scenario is not atypical in developing nations, but unlike other developing countries, Australia has the significant advantage of an abundance of readily accessible dark skies and is amongst the darkest continents globally. However, the propensity to adopt new, perceived more efficient LED technologies, Australia could quickly lose this remarkable asset.

## 6.1. What is a Dark sky Network and Accreditation Program?

A network can be defined in many ways; it can be a series of places notable for adhering to a common set of principles, a collaboration of likeminded or interested people, or an association designed to develop skills and experiences. With the aim of reducing light pollution, a dark sky network should incorporate all: people, places, and culture. This will be achieved through two levels of membership:

> *Level 1* – Basic Network Membership – individuals and organisations that can demonstrate and commit to their immediate environment being dark sky sensitive.
>
> *Level 2* – Accredited Members. This is most likely to benefit groups or organisations, who wish to develop specific dark sky skills, broadens principles and certifies organisations, with the view of creating sub-networks of skilled providers.

## 6.2. Goals for a Dark Sky Network and Accreditation Program

With the benefit of learning from existing international dark sky accreditation programs, the most successful aspects of international programs should also be co-opted into an Australian dark sky conservation effort.

- IDA - globally recognised, strong place making program
- Starlight Fundación – focus on skill and tourism development
- Canadian Royal Society – wider focus on the natural environment

Relationships, should be further strengthened with a partnership MoU, inviting them to be international stakeholders in the Australian network and promoting relevant international accreditation. Likewise, domestic stakeholders from corporate, industry and business (Section 6.6) should be contacted to help initiate the program and unify the currently siloed attempts of light pollution mitigation.

Finally, and perhaps uniquely to this program, equal emphasis should be put on "people" and "place" making, with everyone who becoming a valued member of the Dark Sky Network, demonstrating their commitment to dark sky place making – even if it is only on an individual, home-based scale.

*Table 11- The goals of the Dark Sky Network*

| Goal | Achieved by |
|---|---|
| **Widely engage involvement** | Raise awareness, change habits, in organisations, individuals, and communities |
| **Place making** | Increase area of dark sky conservation nationally through the creation of dark sky places in all environments. |
| **Empower people locally** | Connect people locally with nature and dark sky conservation concepts in a fun, educational and rewarding way |
| **People development** | Develop skills, people, products and breadth of a dark sky community who encourage critical approaches to the use of light at night. (e.g., conservation groups, lighting professionals, councils, educators, urban planners, policymakers, science researchers, and tourism professionals.) |
| **Collaborate** | The inclusion of multiple stakeholders, international and domestic, research partners, local authorities and enforcement agencies |
| **Report and monitor** | Implement and report measurable KPISs that reduce, monitor and map light pollution on local, state and commonwealth levels. |
| **Create sustainable funding streams** | Through membership dues, training and professional development courses, grants and initiatives. |
| **Reduce light pollution** | Bringing people and place together and strengthening dark sky principles, goals and awareness |

## 6.3. Community Conservation and Behavioural Change Models

The following models stand out as effective conservation organisations in Australia, for their impact and ability to engage a wide audience. Whilst achieving their goals, they focus highly on rewarding people for their actions. Most impressively they are scalable; provide financial sustainability, upskill and empower the community or relevant workforce; and develop the next generation of stewardship.

### Zoos Victoria

Zoos Victoria partner with local communities, governments and non-governmental organisations. Their community conservation model *Connect, Understand, Act* mobilises best-practice conservation, education and social science to shape wildlife-friendly attitudes, values and behaviours. This is evidenced in the Lights Off for Bogong Moths, campaign, and another in which over 420,000 people demanded Palm oil labelling and commitment from producers to switch to sustainably grown palm oil.

### Landcare

This highly effective conservation volunteer-led and government supported conservation organisation. Landcare attributes its successful rehabilitation programs and individual and community benefits to the greater sense of connection to community it provides for its 140,000 strong membership base, and 6,000 Landcare sites around the nation.

### SAGE – Science in Australia Gender Equity

SAGE is the only Australian organisation licenced to grant awards under the Athena Swan Charter, enabling organisations to achieve meaningful systemic, structural and cultural change for gender equity. The organisation accredits tertiary education and research institutions for gender equity, diversity and inclusion. Participants are certified on completion of a 24-month cohort training program during which they are required to implement and report on actions that have led to cultural change within the organisation.

## 6.4. Structure of an Australian Dark Sky Network and Accreditation Program

Combining the effective elements of the existing dark sky designation programs and the three behaviour-adapting programs listed in section 6.4, an Australian accreditation program would:

*Connec*t – with a wide audience inviting everyone to register their commitment to dark sky principles

*Understand* – invite groups, individuals and professionals to extend their knowledge and skills in dark sky conservation efforts by attending training, participating in networking events and progressively implementing outreach and light abatement policies within their fields

*Act* – by changing or enacting conservation policies, creating dark sky places, researching impacts of ALAN on the environment, creating new dark sky experiences.

The following diagram depicts how a dark sky network may be established around the country, with the vast majority of members being individuals or organisations (yellow) Conservation groups (green), Tourism suppliers (blue), Cultural Heritage groups (purple) have been certified over time with specific network forucsed, training. Having completed these courses, and implemented strategies, outreach programs or demonstrate compliant lighting, may be suitable for IDA Dark Sky Designation (black).

*Figure 5 Diagram of a Dark Sky Network of people and places and their type of accreditation Model (yellow – individual accredited members, green = conservation groups, purple = cultural heritage focus, blue = tourism focused certified groups, black = existing IDA DSPs.)*

## 6.5. Who Could be an Accredited Member or Organisation?

The goal of the network would be to invite everyone to become a dark sky network member. To do so, registrants must show that they have created their own 'mini' dark sky place by ensuring their home, business or building is dark sky aware. For organisations that wish to demonstrate dark sky environmental outcomes, achieve IDA or dark sky world heritage listings, or obtain professional development skills, the accreditation program would appeal to the following parties.

### 6.5.1. Commonwealth Conservation Areas

National reserves, commonwealth national and marine parks are both numerous and well-known destinations that have been established for their intrinsic natural beauty, value as a resource and have existing conservation mechanisms. Designation of these areas would reaffirm the federal government commitment to the Convention on the Conservation of Migratory Species of Wild Animals and the UN Convention on Biodiversity.

### 6.5.2. Non-government agencies and significant public spaces

Representatives from the following agencies have been chosen for their access to dark skies, ability to reinstate dark sky philosophies or natural environments. These include, but are not limited to:

- Indigenous Protected Areas,
- Astronomical Society of Australia's Designated Observatories,
- Existing Australian IDA places,
- Australian Dark Sky Register Designated Dark Sky Places,
- Significant places of dark sky value (Table 6),

- World, national and commonwealth heritage listed places with DAWE,
- Botanical gardens,
- National zoos,
- Museums,
- Golf courses
- Private land holdings (including Stations and properties listed with the Dawe Associated Partnership Program)
- Landcare, Land for Wildlife, Habitat for Wildlife, Wildlife Conservancy and similar conservation groups
- Australian biospheres,
- Peri-urban and urban areas: Crown land, green belts and general public facilities and open spaces

### 6.5.3. Commercial Operators, Educators, Lighting Suppliers, and Regulators

The inclusion of commercial operators, suppliers and regulators in co-developing training courses, endorsing members and investing in ongoing research and development is critical to the development and successful network outcomes. The following are some recommended for inclusion in our research with councils, and dark sky advocacy groups:

- Energy companies,
- Lighting industry and designers, (IALD, ILCA, IPWEA),
- Public lighting suppliers (e.g. Bunnings, Woolworths, Coles, Mitre 10, Beacon lighting)
- Education groups: Electrical Trade Union, TAFE, (electrical groups, outdoor education, hospitality management),
- Tourism Australia – ecotourism accreditation, Education facilities,
- Green Building Council, Defence, GBCA, urban planners, councillors, department planning)
- State-wide EPBC representatives, and
- Australian Standards representatives

## 6.6. Implementation and Feasibility of an Australian Dark Sky Accreditation Program

The Dark Sky Network Accreditation program may take several months or years to develop and deliver. The SAGE awards training cohorts take two years to reach accreditation. To drive the visibility of the network and rapidly expand the area of dark sky expanse, members should be sought regularly, with the first cohort to participate in the training and accreditation program targeted at national and commonwealth parks, NGOs, public spaces and commercial operators listed in section 6.6, or local government groups. Both of whom would send a significant message to the public of change and night conservation efforts.

The long-term success of the program relies on the strength of an ongoing partnership between the Australian Government and an independent organisation, such as that which exists with Climate Active, or Landcare. Whilst such an endorsement strengthens the messaging government agencies must also be seen to actively engage with dark sky principles. This could be done by; seeking Interdepartmental discussion to reduce light pollution;

adopting light management plans within government buildings or owned areas; and turning lights off for Bogong Moths, Earth Hour and other campaigns. Failure for government to exemplify the change they seek others to make can derail education and awareness campaigns.

## 6.7. Light Pollution Council

As with other environmentally related issues, light pollution should form an organisation to provide independent, authoritative information on light pollution and its solutions to the Australian public, government and industry. The council made up of some of the country's leading environmental scientists, health professionals, lighting industry representatives and policy experts, (SMEs) would provide advice and troubleshoot advancing issues, advocate the reduction of light at night emissions, drive professional standards, underline the value of accreditation and meet regularly to influence strategic decisions pertaining to planning and policy implementation.

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# 8. Appendix A – Background

## 8.2. Survey Highlights

As part of the consultation of this report, ADSA created three surveys with the following number of responses:

1. General public - 620
2. Existing and aspiring Dark Sky Places 39
3. Local Council groups 23

Respondents were invited to participate in the surveys through newsletters, website landing pages, twitter, LinkedIn, and asked their:

- Awareness levels of light pollution strategies including dark sky organisations and place creation, National Light Pollution Guidelines
- The desire to create dark sky places, educate and raise public awareness on impacts
- What would drive change and enhance dark sky environmental outcomes.

Review of responses
*Council Survey*
40% of councils noted that they have areas of relative darkness that should be preserved for their value, and many had heard of the dark sky organisations, but none had intentions to seek dark sky designations.

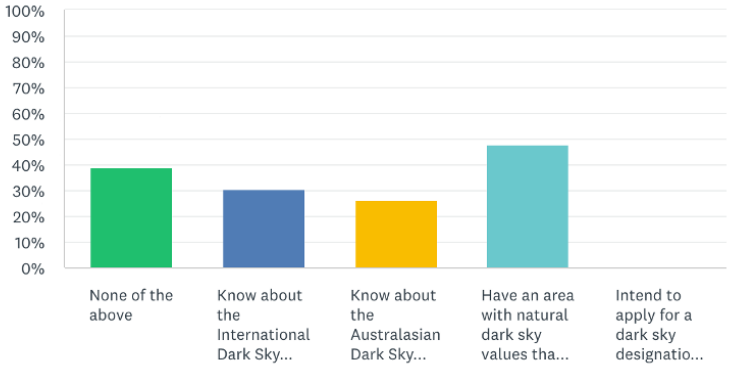


*Figure 6 Council survey responses regarding their awareness of dark sky organisations and intention to create dark sky places in their region*

They reported that the top 4 reasons for not introducing light pollution mitigation strategies in their area were:

1. Cost - good quality lights to retrofit areas, submission and application fees to IDA
2. Lack of regulatory support or awareness of policies for light pollution mitigation
3. Time
4. More pressing conservation issues

They believed they would be likely to create dark sky places, if:

1. Light was listed as a pollutant
2. Government grants or funding were made available to incentivise dark sky awareness raising
3. Access to cheap, good quality dark sky sensitive lighting was readily available
4. Tax incentives for council

*Existing and Aspiring Dark Sky Places*
Whilst more than 80% of respondents in this category would recommend the International Dark Sky Association designation program, they also noted the current complexities of dark sky designation applications for the creation of dark sky places, and the general lack of awareness in Australia of the impacts of light pollution.

These areas responded they were more likely to create dark sky places if there was

1. Interest from local councillors
2. Had access to cheap, good quality lighting
3. Were professional development opportunities for council, lighting industry electricians
4. Government strategies to reduce light pollution
5. Grants and funding opportunities

*General public*
The bias from the survey sample is evident with

- over 90% of respondents acknowledging awareness of the Australasian Dark Sky Alliance
- less than 5% having no existing knowledge of dark sky conservation efforts, and
- 100% reporting they knew of the impacts on wildlife and the environment

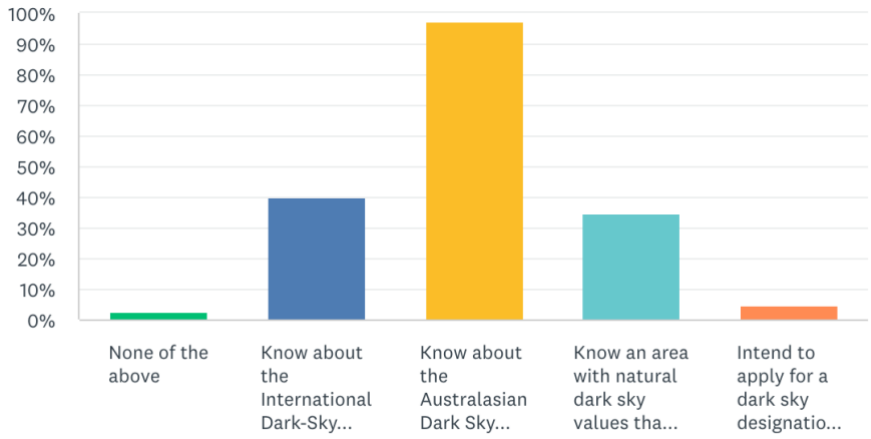


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*Figure 7 - This table shows that most recipients had awareness of dark sky organisations in Australia, but little intention to apply for dark sky designation*

Similarly to councils, the general public reported they would be more likely to create dark sky places if they had access to cheap good quality lighting, light was listed as a pollutant, and there were hands on and awareness raising experiences.

The survey results reiterate the perceived requirement for light to be listed as a pollutant, the desire for dark sky conservation in Australia and the need for government assistance in developing support mechanisms – grant funding, media materials – to help raise awareness.

## 8.3. Value of dark sky tourism

Dark sky places provide the required environment for Astrotourism to flourish. Economic growth has been recorded in areas centred around dark sky places that have been certified. This comes in many forms - provision of stargazing activities, overnight stays with local accommodation providers, purchase of products and souvenirs relating to local dark skies etc. As dark sky places are generally located in rural or remote areas with low levels of economic activity, any economic growth opportunities focusing on sustainability that arise from dark sky accreditation are very much welcomed.

A particularly successful case study that illustrates this is New Zealand's Aoraki Mackenzie's IDA certified International Dark Sky Reserve.

In 2019 and pre-pandemic, Mackenzie district recorded 891,000 guest nights and had more guests staying per resident than any other area in New Zealand – higher than other visitor hotspots like Queenstown-Lakes district and Rotorua district. They grew the second-fastest of any territorial authority in New Zealand over a period of 22 years. Annual guest nights in the September 2019 year were three-and-a-half times the number in the year ended June 1997.

Astrotourism is currently a fast-growing trend with Lonely Planet, Airbnb and National Geographic strongly endorsing it. Post-pandemic growth is forecast to take place in experiential tourism that avoids crowds and linked to nature such as stargazing in a dark sky place

Lonely Planet has published a travel book titled *Dark Skies* that features a number of dark sky places. Its guide for the top 500 things to do in Australia included the Warrumbungle Dark Sky Park as no#1 in NSW – over and above VIVID which was no#2.

*"As Earth grows ever more populous and cities expand, opportunities for humanity to look up at the rest of the universe decrease. Across the planet, travellers are now seeking out the world's last-remaining dark skies where they can get a clear, unpolluted view of the stars."* Lonely Planet 2019.

Airbnb has listed their top destinations to stargaze worldwide and these are worldwide locations and in places with a protected dark sky.

"*Astro-tourism is an environmentally-friendly, authentic and sustainable way to travel that can economically empower lesser-known, rural communities. At Airbnb, we are proud to be boosting this phenomenon thanks to hosts who share their home or passion for astronomy on the platform*. Stargazing is the new healthy travel trend empowering communities." Airbnb 2020

# 9. APPENDIX B - International Accreditation Programs

### 9.2.1. The International Dark-Sky Association (USA)

The International Dark-Sky Association (IDA), was formed by three amateur astronomers in 1988 "to preserve and protect the night-time environment and our heritage of dark skies through quality outdoor lighting". The IDA has over 5,000 members across 70 countries and is the largest organisation devoted to addressing light pollution. The primary focus of the IDA is on returning or maintaining places to their natural state (i.e., a naturally dark sky). The IDA programs include IDA certified Dark Sky Places; fixture seal of approval accreditation of dark sky friendly light fittings; ambassadorship program as well as education and outreach through ongoing webinars and talks. In addition, they partner with mostly American-based government entities to form policy and drive an awards program for dark sky advocacy. Primarily, Australia has been attracted to the Dark Sky Place-making program as the fixture seal of approval and ambassadorship programs, are less viable due to differing electrical standards and time zone issues respectively.

The IDA offers two specific accreditation programs: International Dark-Sky Place Designation and a Home/Building Accreditation Scheme.

*International Dark-Sky Places*
Operating since 2001, this designation scheme offers five different categories of International Dark Sky Place Designation (IDSP); Communities, Parks, Reserves, Sanctuaries and Urban Places. A designation fee of $250USD is incurred when applying for designation. To date, there are 195 International Dark Sky places globally including three in Australia; Warrumbungle National Park Dark Sky Park NSW; River Murray River International Dark Sky Reserve SA, and the Jump Up Sanctuary near Winton, Qld. A further four places in Australia are currently under application - Gravity Centre, WA - Reserve, Palm Beach Headland, NSW Urban Dark sky Place, Carrickalinga – South Australia, Community, Arkaroola, South Australia, Sanctuary

*International Dark-Sky Home and Building Accreditation Scheme*
This scheme is targeted at the individual and businesses aiming to reward those who can demonstrate dark sky lighting within their home or business setting. Despite it being free and relatively easy to achieve, this has not been widely adopted by the Australian audience. Attempts by the Australasian Dark sky Alliance to co-deliver this nationally were ceased due to the high volume of enquiry associated with rectifications, and inability to raise sufficient funding to market and sustain the program satisfactorily.

### 9.2.2. Starlight Foundation (Fundación Starlight) (Spain)

The Starlight Foundation (Spain, commenced 2009) promotes astronomy and sustainable, high-quality astrotourism ventures. As a non-profit organisation they protect the Dark sky from light pollution by raising awareness, adoption and innovation of smart lighting technologies, energy saving and cultural dissemination of astronomy. The Starlight Foundation accreditation program has multiple categories including tourist destinations, reserves, rural hotels, and camps. Multiple training courses are also run for tourist guides, monitors, auditors, and lighting technicians. There are currently no Starlight Foundation places in Australia.

*Figure 9 - Locations of Starlight Foundation places. Jan 29, 2022*

The Starlight Foundation views education and training as the foundation of preserving dark skies. Promotion of quality astrotourism is a major element of its education Starlight Astrotourism. The foundation delivers courses for aspiring and existing accommodation venues on delivering quality astrotourism. Courses include Starlight Tourist Guide/Monitors; Starlight Auditors; Prevention of Light Pollution and Starlight Lighting Technician. these are worth of further investigation by someone who speaks and reads Spanish. In 2021 the foundation ran a conference on accommodation for astrotourism.

### 9.2.3. Dark Sky Sites (Canada)


*Figure 10- Canadian Preserve locations (Feb 2022)*

The Royal Astronomical Society of Canada operates a Dark Sky Site Program in co-operation with the International Dark-Sky Association. There are three categories and 32 Preserves currently listed (Figure 10). As Dark sky Preserve, Nocturnal Preserve, or Urban Star Parks. The complexity of application is comparable to the IDA programs, but more relevant to Australia as it focuses on protection of fauna and flora. The organisation has recently stalled applications due to the high volume of submissions and a lack of qualified volunteers to assess them.

## 9.3. Australian Accreditation Programs

Australia has two existing accreditation programs; The Australian Dark Sky Register focused on increasing dark sky places, and ADSA Approved which independently certifies luminaires for use by councils and planners in outdoor spaces.

### 9.3.1. Australian Dark Sky Register

The Australian Dark Sky Register (Developed in 2015) is a volunteer-led organisation promoting the preservation of the environment and the dark sky. It focusses on the efforts of individuals, groups and communities to reduce light pollution attributed to bad lighting practices. The Register replicates many aspects of the IDA accreditation, but it is an independent accreditation process that is not recognised by the IDA or ADSA. There are currently four certified sites being Norfolk Island, Snake Valley, Victoria, Southport Community Centre, Tasmania and Lake Ballard Campground, Western Australia. As with internationally based dark sky place-making certifiers, this organisation has had little impact in extending dark sky awareness further than the registered places but could serve as a valuable partner in the development of a Dark sky Network across Australia. The qualifications and experience of the personnel assessing applications is unknown or understood to be limited.

### 9.3.2. Australasian Dark Sky Alliance and ADSA Approved

The Australasian Dark Sky Alliance (ADSA) is a charitable organisation that offers a paid accreditation scheme, ADSA Approved, that independently certifies industry luminaires into one of three categories - ADSA Approved, ADSA Prized and Wildlife Sensitive. Each categories mandate 0% upward wastelight; are ranked respectively for their correlated colour temperature, and regularly update a database suitable for use by planners and councils. Accreditation fees paid by the manufacturers assist the ongoing education efforts that ADSA provide. Whilst the program is in its infancy, there has been a steady growth of interest and application, - as of April 2022, the list contains five manufacturers, and 380 luminaires. This program could be further expanded or adopted by governing bodies to assist it the creation of dark sky places and developers looking to comply with dark sky principles. Parklands such as Riverbend, Launceston TAS; Milparinka Starpark NSW and the Urban Dark sky Place Palm Beach NSW have or will incorporate ADSA Approved products. ADSA promotes the designation of dark sky places through a memorandum of understanding with the International Dark Sky Association.

## 9.4. Review of accreditation programs

The above international and domestic accreditation schemes report a lack of funding, reliance on volunteer administration and their charitable status as the biggest obstacles in achieving the desired outcomes. While charitable status is beneficial in engaging donation and tax incentives, it may engender a public perception that the organisation should not run as a business, and services should be free. The combination of scarcity of funding and little current penetration of the topic of light pollution issues undermine the engagement of a philanthropic

audience. This can lead to competitive behaviours between the organisations vying for limited funding.

In summary, dark sky place designation provides an area that can preserve the night environment values of an area, but often fails to enlist a wide following not even reaching far beyond the attention of local communities. These reviewed programs primarily champion the place (place), and latterly focus on those who have created or preserved them (people), place little emphasis on science-based research or solutions (science) and seek stakeholder engagement subsequently for event sponsorship or in-kind support roles (funding). With these models in mind and the benefit of learning from others, dark sky initiatives in Australia should reverse this order; people should feel rewarded for their efforts, connected to nature and excited to be a part of an advancing conservation effort; research and development should guide policy and change-making decisions; and stakeholder partnerships should be sought and activated to drive the desired outcomes. Dark Sky Place designation should result from these actions.

# 10. Appendix C International Dark Sky Conservation

### 10.2.1. France

The most significant move to legislate light pollution was enacted in France, in 2019. Initiated by the Association National pour la Protection du Ciel et de l'Environment Nocturnal (ANPCEN), France established a national-level policy to reduce the growth rate of both the lit area and the intensity of upward-directed light (Decree of 27 December 2018;) as a result, annual light pollution in France decreased by 6% after the enactment of artificial light legislation. (Aksaker 2020). A Case study of light pollution in France after the change in legislation. In summary, the decree states that, "Emissions of artificial light from outdoor lighting installations and indoor lighting installations shining towards the outside are designed to prevent, limit, and reduce light pollution, particularly any excessive disturbance to persons, fauna, flora, or ecosystems, leading to wasted energy, or preventing observation of the dark sky". The decree has a prescribed calendar of events (some relating to previous orders) with a hard deadline of 1st January 2025 to eliminate any lights/lighting that have more than 50% of their light spilling upward. Aside from recommendations for light spill and intensity, the decree mandated Correlated Colour Temperatures (CCT) of ≤ 2400K near observatories and recreational parks. While there was initial concern regarding its practicality, this mandate has driven commercially viable products, with chips as low as 2200K LED chips for use by outdoor luminaire manufacturers.

### 10.2.2. United Kingdom

The All-Party Parliamentary Group for Dark Skies (United Kingdom) was formed in 2020. The party, which includes parliamentarians of all parties from both the House of Commons and House of Lords released the 'Ten Dark Sky Policies for the Government' in consultation with over 170 academics, legal professionals, national park associations, professional and amateur astronomers, members of local and national government, lighting professionals, engineers and businesses. It aims to modernise current approaches to light pollution challenging the existing legal framework; overhaul rules applicable to outdoor lighting installations; and introduce new initiatives at every level of government that educate and incentivise the reduction of light pollution and obtrusive light. The goals are noteworthy and given the common form of governance between United Kingdom and Australia, could be readily adopted and, thus, align with the recommendations from this paper. Actions by the group appear static since early 2021 and have been hindered with problems of compliance and enforcement. They note that the concept may have been targeted poorly focusing on 'dark skies' rather than the larger impacts of ALAN.

### 10.2.3. International Union for the Conservation of Nature (IUCN) World Congress

In 2021, the IUCN successfully moved motion 084 in a global bid to take action to reduce light pollution. The motion, which was overwhelmingly adopted, encourages all IUCN Members (including Australia) to develop "education and outreach programmes to explain the harmful impacts of light pollution, the benefits of preserving natural darkness, and methods to reduce light pollution, with such programmes being directed at all appropriate stakeholders, including but not limited to, visitors, users, private and corporate residents." In support of the motion,

an advisory group and several recommendations have been formed including a variety of place-making opportunities. Whilst this a significant, this is a non-binding international agreement.

### 10.2.4. World Heritage Listing

World Heritage sites are highly prized, widely recognised and have legal protection by an international convention administered by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and have cultural, historical, scientific or other form of significance. Australia currently has 20 properties on the World Heritage List.

In 2017, the Astronomy World Heritage Initiative was formed, as a collaboration between UNESCO and the IAU focusing on the sky as the "common and universal heritage". Since then, three Astronomy sites have been added to the World Heritage List; Jodrell Bank Observatory in the United Kingdom (2019), Risco Caído and the sacred mountains of Gran Canaria Spain (2019), and Chankillo solar observatory in Peru (2021) based on their astronomy or archaeoastronomy values. These listings suggest that the preservation of dark skies is likely to become a key consideration for future World Heritage property listings.

The Warrumbungle Dark Sky Park, Mount Stromlo, Honeysuckle Creek, the Parkes Dish, Murchison Array Telescopes may successfully qualify as similar World Heritage areas. Hortobágy Puszta in Hungary is both a World Heritage site and an IDA International Dark Sky Park. The nomination documents for WHL should be emulated for dark sky place making applications.

### 10.2.5. International Astronomical Union

The International Astronomical Union (IAU) and United Nations Office for Outer Space Affairs (UNOOSA) have held two conferences focusing on the urban illumination or artificial light at night; optical trails of satellites in low Earth orbits; and radio transmission by ground and space emitters that affects radio astronomy. Australia was represented by the Department of Industry Science and Energy and Resources. Public interest in the Starlink satellite constellations has brought a new perspective on the dark sky and is increasing the public focus on dark sky conservation. Whilst the goals and political support of the union are weighty, they do not allow the general public to engage widely in support efforts, and tend to be space, not land, focused.

### 10.2.6. United Nations

The United Nations Sustainable Development Goals (SDG) provide further stimulus on the issue of light pollution. Focusing on the protection of ecosystems on land and in the water, some protection may fall under SDGs 14 and 15. Anecdotally the full suite of goals is noteworthy and understood in the northern hemisphere but are little known in Australia.

### 10.2.7. New Zealand

The Royal Society of New Zealand produced Blue Light Aotearoa, in 2018, which is a summary of the scientific evidence of the effects and growing concerns of exposure to artificial blue light outside daylight hours. The document that raises concerns from lighting and digital

screens on human health, wildlife and the dark sky, should be replicated and extended within an Australian context.

### 10.2.8. Croatia

In 2019, the Croatian Ministry of the Environment and Energy, various government ministries and the astronomical society enacted the national Croatian Light Pollution Protection Act 2019. This planning tool prevents excessive light emissions, limits blue light content, and prohibits upward light or light over natural water sources. Best practice lighting is enforced through a robust inspection regime and includes the submission of light plans. The most recent research on light pollution in Croatia (Andreic,2011), determined most of the country was moderately polluted by light, apart from several islands and some areas in Lika and Gorski Kotar. At the time of its release, the Croatian regulations relating to light pollution were in discussion. Further research is required to determine the extent of the difference the Act has made.

# 11. Appendix D RECCOMENDED DARK SKY PLACE CANDIDATES AUSTRALIA

*Table 12: Overview of places recommended for accreditation including ^urban areas*

| Aspiring Dark Sky Place | State | Classification | Tourism infrastructure | Astronomy interests | Ecological value | Cultural sensitives |
|---|---|---|---|---|---|---|
| Australian National Botanic Gardens^ | ACT | Commonwealth National Park | Y | | Y | Y |
| Mount Stromlo Observatory^ | ACT | Observatory | Y | Y | | |
| Namadgi National Park (Tidbinbilla) | ACT | National Park | Y | Y | Y | Y |
| Christmas Island* | EXT | Commonwealth National Park | Y | | Y | Y |
| Mawson's Huts Antarctica* | EXT | National Heritage List | Y | | Y | |
| Norfolk Island National Park* | EXT | Commonwealth National Park | Y | Y | Y | |
| Pulu Keeling National Park* | EXT | Commonwealth National Park | | | Y | Y |
| Booderee National Park | NSW | Commonwealth National Park | Y | | Y | Y |
| Greater Blue Mountains | NSW | UNESCO World Heritage Site | Y | Y | Y | Y |
| Lord Howe Island Group* | NSW | UNESCO World Heritage Site | Y | | Y | |
| Observatory Hill (Sydney Observatory) ^ | NSW | Observatory | Y | Y | | |
| Royal National Park Garawarra State Conservation Area^ | NSW | National Heritage List | Y | | Y | Y |
| Australian Alps National Parks and Reserves | NSW, ACT, VIC | National Heritage List | Y | | Y | Y |

| | | | | | | |
|---|---|---|---|---|---|---|
| Kakadu National Park | NT | Commonwealth National Park, National Heritage List | Y | | Y | Y |
| Uluru - Kata Tjuta National Park | NT | Commonwealth National Park UNESCO World Heritage Site | Y | Y | Y | Y |
| Bunya Mountains National Park | QLD | National Park | Y | Y | Y | Y |
| Glass House Mountains National Landscape | QLD | National Heritage List | Y | | Y | Y |
| Great Barrier Reef | QLD | UNESCO World Heritage Site | Y | | Y | Y |
| K'gari (Fraser Island) | QLD | UNESCO World Heritage Site | Y | Y | Y | Y |
| Wet Tropics of Queensland | QLD | UNESCO World Heritage Site | Y | | Y | Y |
| Australian Fossil Mammal Sites (Naracoorte) | SA | UNESCO World Heritage Site | Y | | Y | Y |
| Ediacara Fossil Site - Nilpena | SA | National Heritage List | Y | Y | Y | Y |
| Darlington Probation Station | TAS | UNESCO World Heritage Site | Y | | Y | Y |
| Port Arthur Historic Site | TAS | UNESCO World Heritage Site | Y | Y | Y | |
| Recherche Bay (Northeast Peninsula) Area | TAS | National Heritage List | Y | Y | Y | Y |
| Tasmanian Wilderness | TAS | UNESCO World Heritage Site | Y | | Y | Y |
| Western Tasmania Aboriginal Cultural Landscape | TAS | National Heritage List | Y | | Y | Y |
| Abbotsford Convent^ | VIC | National Heritage List | Y | | Y | Y |
| Budj Bim National Heritage Landscape | VIC | UNESCO World Heritage Site | Y | | Y | Y |
| Echuca Wharf | VIC | National Heritage List | Y | Y | Y | Y |
| Grampians National Park (Gariwerd) | VIC | National Heritage List | Y | Y | Y | Y |

| | | | | | | |
|---|---|---|---|---|---|---|
| Great Ocean Road | VIC | National Heritage List | Y | Y | Y | Y |
| Karijini National Park | WA | National Park | Y | Y | Y | Y |
| Kings Park | WA | Class- A reserve | Y | Y | Y | Y |
| Nambung National Park (The Pinnacles) | WA | National Park | Y | Y | Y | Y |
| Rottnest Island | WA | Class- A reserve | Y | Y | Y | Y |
| The Ningaloo Coast | WA | UNESCO World Heritage Site | Y | Y | Y | Y |

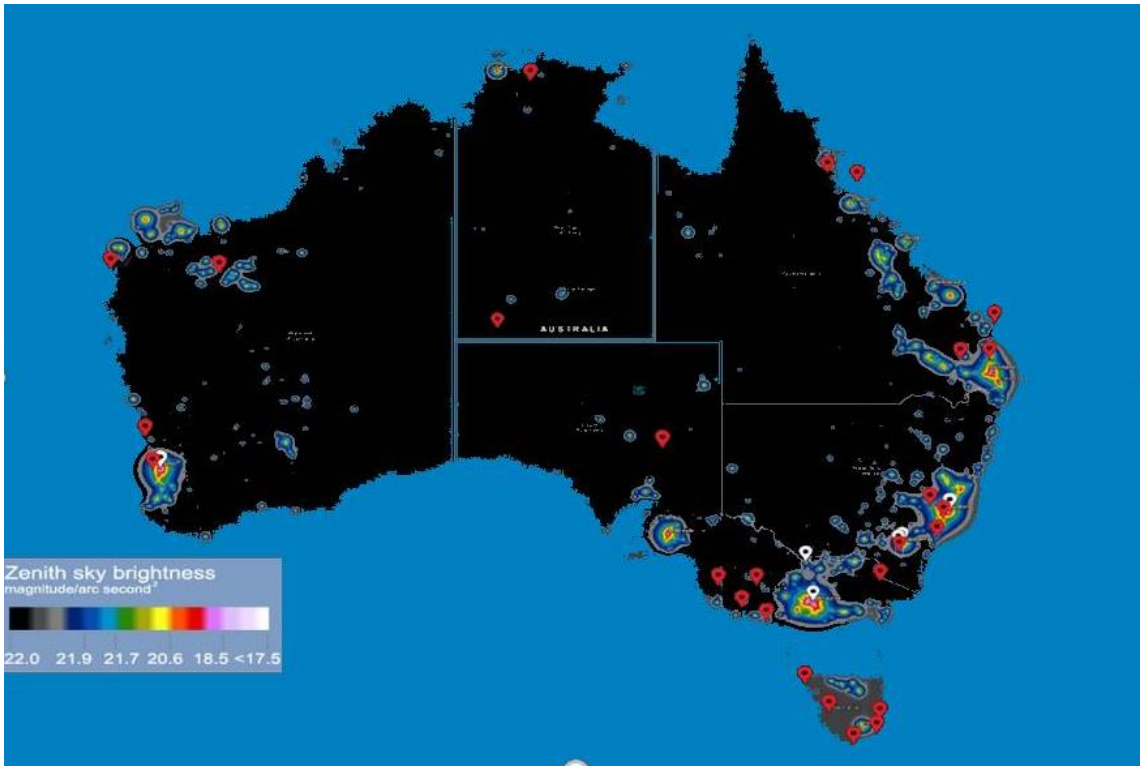



*Figure 11 - Locations of the recommended dark sky places (37 sites). Red pins located in the centre of each site*

## 11.2. Justification for Site Selection

### World Heritage Sites and Commonwealth National Parks

The commonwealth government manages seven national park sites; six national parks (three in external territories and three on mainland Australia), and the National Botanic Gardens in Canberra.

These commonwealth national parks are typically designated because of their outstanding natural beauty, high biodiversity and high and often globally recognised conservation, positioning them as ideal candidates for Dark Sky Places. Managed by a single government entity, commercial development must be consistent with sound environmental management principles. Most of these parks are well-known and well-attended by both national and international visitors. Park boundaries are typically characterised by dark skies free of artificial light pollution. Designation of these parks would signal a firm commitment from the Australian federal government on the impacts of light pollution and ambitions for abatement.

These seven sites have been mapped and the light pollution quantified from within the park boundary and within a 20km buffer zone around the park (Section 11.3.1).

## Other areas for dark sky designation

### Regional or Rural Sites

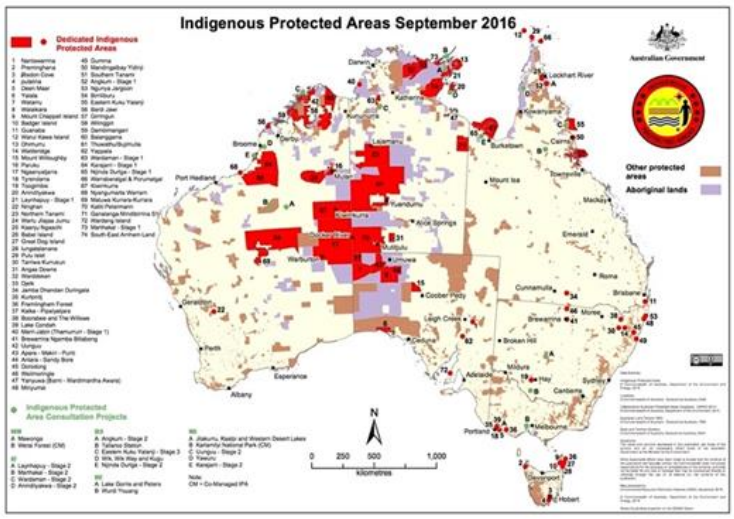



*Figure 12- Indigenous Protected areas*

The strong cultural connection and heritage associated with the dark sky and First Nations people was addressed in Section 2. The seventy-eight dedicated Indigenous Protected Areas (IPAs) across the continent total 46% of the National Reserve System. These areas are mostly non-light polluted, categorised under the International Union for Conservation of Nature (IUCN) Protected Area Management system as Categories 5 (V Protected Landscape/ Seascape, valued for biodiversity) and 6 (Protected area with sustainable use of natural resources). Their accreditation is recommended due to their existing unpolluted status, geographic importance to regional night-time conservation, economic benefit to local custodians and cultural heritage preservation. Under the IDA accreditation program they would not comply as they are unincorporated lands.

### Urban and Peri-urban Areas

This review identified Landcare as a potential partner and collaborator for developing and managing dark sky network members in both remote and urban areas. Established over 30 years ago and widely respected and recognised by the Australian community, their conservation activities are carried out by over 140,000 volunteers in coastal rural, urban, and outback regions at more than 5,000 destinations around the country. The success of the River Murray Dark Sky Reserve, the second place in Australia to be certified by the IDA as a dark sky site, and first Reserve, is largely credited to the support of the Landcare volunteers in the region. As noted by representatives of Landcare itself, this has forged an understanding of the dark sky principles that they are keen to further pursue. Whilst Landcare stands out as a valuable partnership, all urban-based conservation organisations listed in section 6.6.3 should be considered.

### Functional Urban Spaces

In addition to Landcare, this review has identified additional opportunities for dark sky protection, including facilities such as zoos (100+), botanical gardens (140+) and golf courses (~2235) located throughout Australia. These generally under-utilised, prime greenspace areas could provide corridors of darkness and refuge for biodiverse ecosystems and expand the hours and type of audience engagement in these areas. This has been exemplified by Maleny Golf Course, which adopted dark sky principles in 2016, was listed by the Astronomical Society

of Australia as an observatory and subsequently received over $200,000 grant funding to upgrade facilities.

## 11.3. Dark Sky Mapping

These seven commonwealth national park sites have been mapped and the light pollution quantified from within the park boundary and within a 20km buffer zone around the park. Light emissions were quantified using Visible Infrared Imaging Radiometer Suite (VIIRS) data provided by the joint NASA/NOAA Suomi National Polar-orbiting Satellite Light emissions from 2015 and 2020 were quantified to provide a time series in artificial light emissions. This data is publicly available on the lightpollutionmap.info site, a source that is accessible, intuitive and recommended as one of the tools that could be used to support the Australian Dark Sky Network Accreditation Scheme. The mean radiance values within the park boundary and within the 20km buffer zone were calculated by dividing the mean light value for all the pixels within the park boundary by the area within the boundary. So, for parks with little light within a small area the mean radiance value will be small compared to parks with a lot of light within a small area which will have a very high mean radiance value.

This review has identified thirty-five areas as potential candidates suitable for accreditation as a Dark Sky Place (Appendix D) and include:

- regional or remote Sites which are inherently dark, and
- urban or peri-urban areas which includes areas that may be light polluted but offer significant opportunity for dark sky education.

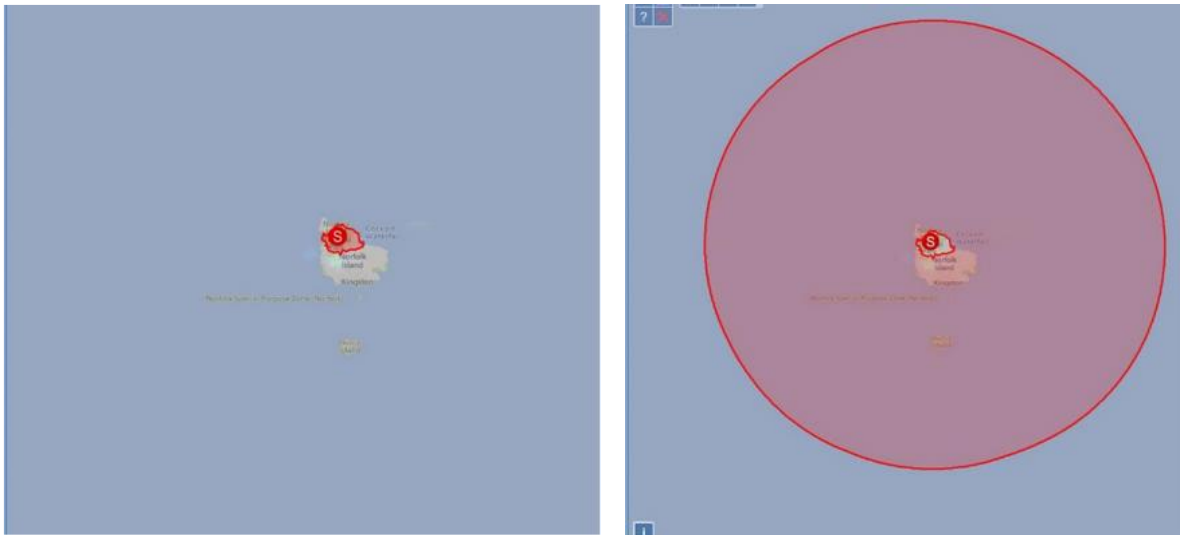
The sites were assessed against the following criteria.

- accessibility to dark skies,
- ability to educate dark sky principles.
- high and current conservation value (Commonwealth National Park, a World or National Heritage Listed place);
- ability to attract large numbers or incorporate existing tourism facilities.
- valuable astronomical areas (culturally or scientifically);
- First Nation or Western cultural values;
- develop economic stimulus as a result of dark sky accreditation

### 11.3.1. Dark Sky Mapping – Commonwealth National Parks

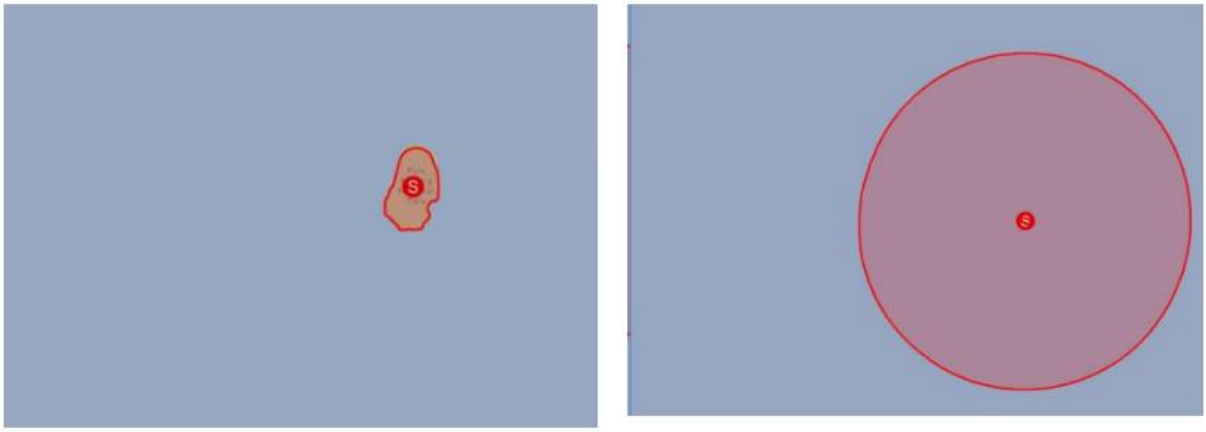
**Boundary of property** **20km buffer radius property**

Uluru National Park

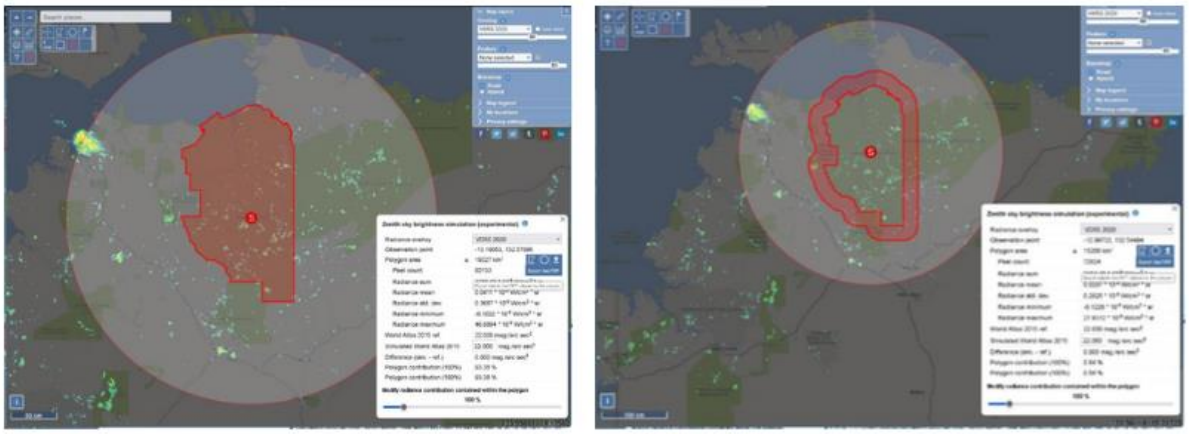


Norfolk Island

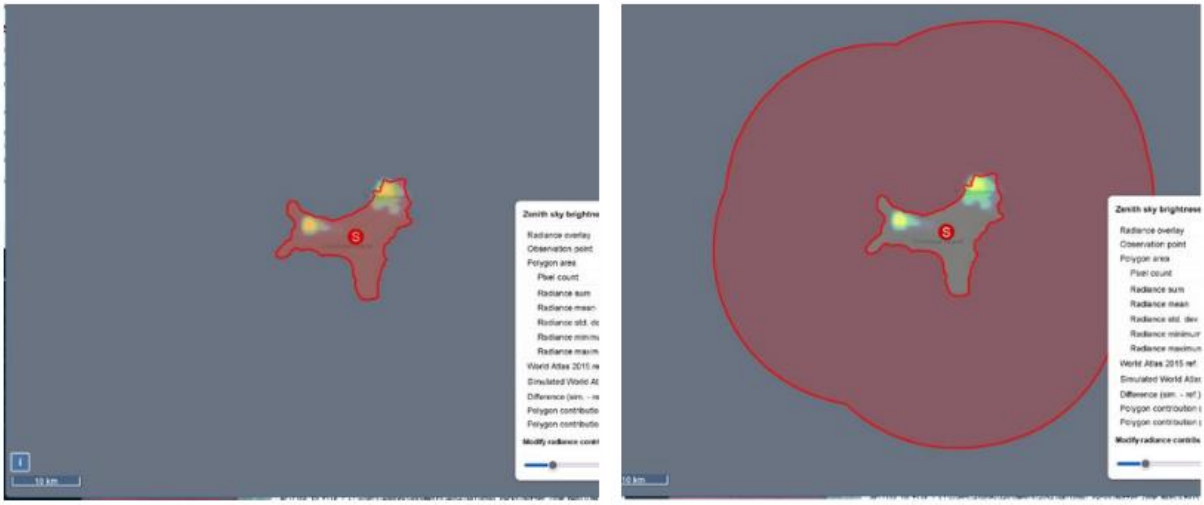
*Figure 7 Commonwealth National Parks light pollution mapped with a 20km radius*



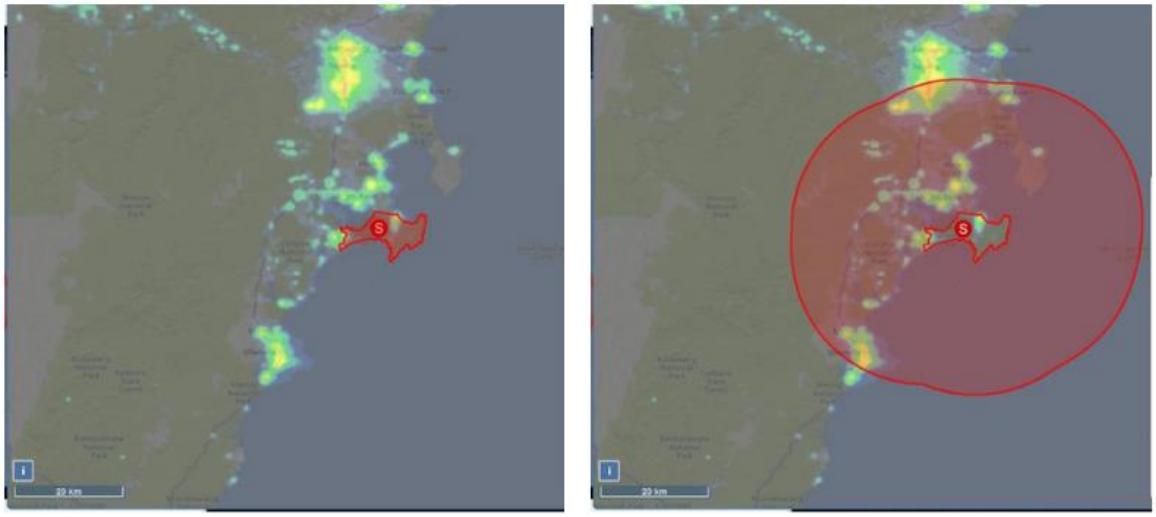
Cocos Keeling National Park



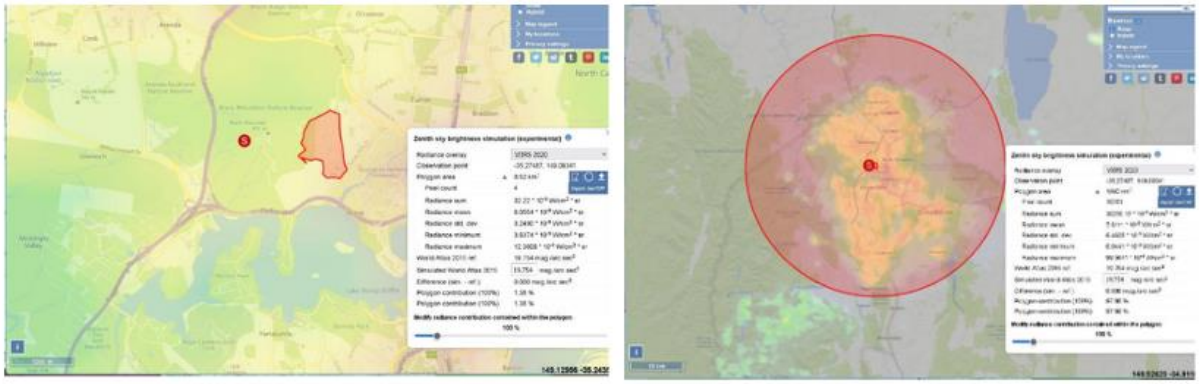
Kakadu National Park



Christmas Island



Boderee National Park



National Botanical Gardens

# 12. Appendix E: Assessment of Noise & Light as Pollutants

Noise and light pollution are two forms of non-traditional environmental pollutants that effect on human and ecological health. With the proliferation of sources of noise and light in expanding urban environments, both should be listed as a pollutant (Johnson 2022), but only noise has regulatory enforceable standards. Like light, it shares its traits as a sign of poor urban planning, relying on old standards without adopting new principles or technology or not introducing best-practice standards. With increased urbanisation of the globe, the impacts of noise pollution (stress, impaired cognitive function, loss of hearing) were reduced by the adoption of regulations to reduce noise emitted from construction equipment, transportation equipment, any motor or engine, and electrical or electronic equipment in the Noise Control Act (NCA) of 1972. This resulted in noise emission limits on air compressors, motorcycles, medium and heavy trucks, and truck-mounted waste compactors (Hammer 2014).

In all States and Territories in Australia the Environmental Protection Authority lists noise as a pollutant. The EPA regulates and limits noise emissions on a state-by-state basis enforcing noise control regulations in partnership with local government, Police and Roads and Maritime Services. Using practices set out in the Industrial Noise Policy, research and the most effective technologies and techniques they can assess potential noise impacts, and determine maximum levels from noise sources (time, and decibel figure 8) for licensed industrial premises, neighbourhood, vehicles and transport noise. The community plays an important part by reporting incidents whilst Local councils have the power to issue notices and fines to people and businesses requiring them to control offensive noise, and to educate them on what noise levels are acceptable.

The EPA produce a series of free, widely available publications on various forms of pollution, how they can be mitigated, and the contact agency should there be enquiries.

| Location of noise source | Noise source | When is noise not allowed?* | Who to contact |
|---|---|---|---|
| Residential premises | Motor vehicles (except when entering or leaving residential premises*) | Before 8 am and after 8 pm on weekends and public holidays<br>Before 7 am and after 8 pm on any other day | • Council, or<br>• NSW Police Assistance Line, phone 131 444 |

| Australian Design Rule (ADR) that applies | Vehicle type and date | Maximum exhaust noise level |
|---|---|---|
| Earlier than ADR 83/00 | Cars built before 1 January 1983 | 96dB(A) |
| | Cars built on 1 January 1983 or later | 90dB(A) |
| | Motorcycles designed or manufactured for use on a road, and built on or after 1 March 1984 | 94dB(A) |
| | Other motorcycles | 100dB(A) |

*Figure 13 Example of noise restrictions, who to contact and source of noise pollution from NSW EPA Motor Vehicle Noise Pollution*

NSW Regulations include the:

- Protection of the Environment Operations Act 1997, (POEO)
- Noise Policy for Industry (2017),
- NSW Industrial Noise Policy

Noise pollution regulations offer a working, multijurisdictional model for light pollution regulation specifically adapting the quantitative and qualitative metrics of the light source (horizon imaging, colour temperature (CCT), blue light content, time of use (curfew), adaptively controlled, intensity) governing body, to the natural environment in which it is found.

*Table 8 - Proposed approach for light pollution regulations showing issue, regulatory body and metric for light pollution*

| Environment | Issue | Governing body | Metric |
|---|---|---|---|
| Private residency | Light Trespass | Police, local council | Light intensity, curfew, adaptive controls |
| Turtle Nesting Beach | Species | EPA | Horizon imaging, blue light content, |
| Sports stadium | Light Trespass, Glare | State government | Above the horizontal plane, intensity, curfew |