Appendix 1

The StarLight Conference 2007

Declaration in Defence of the Night Sky and the Right to Starlight (La Palma Declaration)

The complete document can be found at:
http://www.starlight2007.net/pdf/StarlightDeclarationEN.pdf

The participants in the International Conference in Defence of the Quality of the Night Sky and the Right to Observe the Stars, meeting in La Palma, Canary Islands, Spain, on the 19th and 20th of April 2007, jointly with the representatives of UNESCO, UNWTO, IAU, UNEP-CMS, COE, SCBD, MaB, EC and Ramsar Convention,

Aware that a view of the starlight has been and is an inspiration for all humankind, that its observation has represented an essential element in the development of all cultures and civilisations, and that throughout history, the contemplation of the firmament has sustained many of the scientific and technical developments that define progress;

Guided by the principles announced in the preamble of the Explanatory note concerning Proclamation of 2009 as International Year of Astronomy (33rd session of the UNESCO General Conference) that defines the sky as a common and universal heritage and an integral part of the environment perceived by humankind;

Recalling that humankind has always observed the sky either to interpret it or to understand the physical laws that govern the universe, and that this interest in

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

astronomy has had profound implications for science, philosophy, culture, and our general conception of the universe;

Recognising that the quality of the night sky and thus the capacity to access the light of stars and other celestial bodies within the universe is deteriorating at an alarming rate in several areas, that its contemplation is increasingly difficult, and that this process faces mankind with the generalised loss of a cultural, scientific, and natural resource with unforeseeable consequences;

Conscious that the deterioration of the clarity of the night space has started to emerge as a serious risk to the continuity of astronomic observations, a branch of science that presently provides a flow of direct and indirect benefits which are increasingly valued;

Bearing in mind that the Rio Conference of 1992 proclaimed the necessary defence of the "integral and interdependent nature of the Earth", and that this defence naturally includes the dimension of the night skies and the quality of the atmosphere;

Acknowledging that the Universal Declaration of Human Rights of Future Generations states that persons belonging to future generations have the right to an uncontaminated and undamaged Earth, with pure skies, and are entitled to enjoying these as the ground of human history of culture and social bonds making each generation and individual a member of one human family;

Mindful of the validity of the Universal Declaration of Human Rights, adopted by the General Assembly of the United Nations, and of the different international declarations on sustainable development and the conventions and protocols concerning the environment – all these safeguarding cultural diversity, biological diversity, the landscape, and thus the conservation of cultural heritage and combating climate change, all of which have a direct or indirect influence on the need to safeguard the clarity of the night skies;

Considering that the scientific, cultural, educational, environmental, safety, and energy benefits of preserving a dark night sky need urgent attention and action;

Aware of the need to establish efficient and urgent alliances among the leading players, whose decisions can have an influence on reversing the process of degradation that is affecting the quality of the night sky, with a view to providing all the possible assistance needed to protect and conserve the cultural and natural heritage of Starlight;

APPEAL to the International Community, and, in particular, **URGE** governments, other authorities and public institutions, decision-makers, planners and professionals, private institutions and associations concerned, the world of science and of culture, and all citizens individually, to adopt the following principles and objectives of this declaration:

1. An unpolluted night sky that allows the enjoyment of the contemplation of the firmament should be considered an inalienable right of humankind equivalent

to all other environmental, social, and cultural rights, due to its impact on the development of all peoples and on the conservation of biodiversity.

2. The progressive degradation of the night sky must be considered an imminent risk that must be faced, in the same fashion as the main problems concerning resources and the environment are addressed.
3. The conservation, protection, and revaluation of the natural and cultural heritage associated with night landscapes and the observation of the firmament represents a prime opportunity and obligation for cooperation in safeguarding the quality of life. For all decision-makers, this attitude implies a genuine challenge involving cultural, technological, and scientific innovation, requiring a major constant effort to enable us to rediscover the presence of the night sky as a living part of our heritage.
4. Access to knowledge, armed with education, is the key to allow the integration of science into our present culture, contributing to the advance of humankind. The dissemination of astronomy and the scientific and cultural values associated with the contemplation of the universe should be considered as basic contents to be included in educational activities, which require a clear and unpolluted sky and proper training of educators in these subjects.
5. The negative effects of emissions and of the increased intrusion of artificial light on the atmospheric quality of night skies in protected areas have an impact on several species, habitats, and ecosystems. Control of obtrusive light must be a basic element of nature conservation policies and should be implemented in the management plans of the different types of protected areas to fulfil their mission in protecting nature and biological diversity.
6. Mindful that a starry night sky forms an integral part of the landscape perceived by the inhabitants of every territory, including urban areas, the landscape policies established in the different juridical systems need to adopt the pertinent standards for preserving the quality of the night sky, thus allowing them to guarantee the common right to contemplate the firmament.
7. The intelligent use of artificial lighting that minimises sky glow and avoids obtrusive visual impact on both humans and wildlife has to be promoted. Public administrations, those in the lighting industry, and decision-makers should also ensure that all users of artificial light do so responsibly as part of an integral part of planning and energy sustainability policies, which should be supported by light pollution measuring, both from the ground and from space. This attitude would involve a more efficient use of energy so as to meet the wider commitments made on climate change, and for the protection of the environment.
8. Areas suitable for unimpaired astronomic observation constitute an asset in short supply on our planet, and their conservation represents a minimum effort in comparison with the benefits they contribute to our know-how and to scientific and technological development. The protection of sky quality in these singular places must be given priority in regional, national, and international scientific and environmental policies. The measures and provisions must be made to safeguard clear skies and to protect such spaces from the harmful effects of light, radio-electric emissions, and air pollution.

9. Among others, tourism can become a major instrument for a new alliance in defence of the quality of the night sky. Responsible tourism can and should take on board the night sky as a resource to protect and value in every destination. Generating new tourist products based on the observation of the firmament and the phenomena of the night, opens up unsuspected possibilities for co-operation between tourism stakeholders, local communities, and scientific institutions.
10. Sites included in the World Network of Biosphere Reserves, Ramsar Wetlands, World Heritage Sites, National Parks, and all those protected areas which combine exceptional landscape and natural values relying on the quality of their night sky, are called for including the protection of clear night skies as a key factor strengthening their mission in protecting nature.

    All the necessary measures should be implemented to inform and to raise awareness among all the main actors involved in protecting the night environment, be it at local, national, regional, or international level, of the contents and the objectives of the International Conference in Defence of the Quality of the Night Sky and the Right to Observe the Stars, held on the Island of La Palma.

Final Resolutions

The International Conference in Defence of the Quality of the Night Sky and the Right to Observe the Stars considers it essential to make the following public appeals:

1. In consonance with the principles announced in this Declaration, the Conference invites the authorities of States to take appropriate measures in order to safeguard the cultural and natural heritage of Starlight, and formulate actions plans to provide effective protection of night sky, particularly in areas of interest for astronomic observation, protected areas that are sensitive to the loss of natural light from the night, and places of special importance related to astronomical heritage.
2. The Conference agrees to refer the Declaration on the Defence of the Night Sky and the Right to Starlight to the Director-General of UNESCO for its acknowledgement and, if appropriate, recommendation to the Agencies and Bodies of the United Nations system as well as to the International Conventions related with the principles and objectives approached by the Declaration and other organisations directly involved, such as the IAU (International Astronomical Union).
3. At the request of the Canary Islands Government, once it has been adopted at a meeting of the Canary Islands Government Council in April 2007, the Conference decides to submit a proposal to UNESCO through the Spanish Government to declare March 21st a World 'Right to Observe the Stars' Day. The campaign will be launched under the name "The World Night".
4. The Conference proposes to the UNESCO-MaB Secretariat to present the final conclusions and achieved agreements at the 3rd World Biosphere Reserves

Congress, to be held in Madrid in 2008, with a view to include night sky protection, if appropriate, into the new Action Plan for Biosphere Reserves, acknowledging the important role that Biosphere Reserves can play as a network of true sustainable development laboratories.

5. The Conference requests the five Conventions in the Biodiversity Liaison Group, to examine the outcomes of its deliberations and, if appropriate, take to their governing bodies a combined view of the role of the conventions in helping increase protection for the night sky, understanding that this action will have positive effects on the conservation and wise use of biodiversity. The Conference also recommends to the IUCN (World Conservation Union) to examine this issue at its 4th World Conservation Congress foreseen for Barcelona in late 2008.
6. The Conference requests the UNESCO World Heritage Centre to inform the World Heritage Committee at its 31st session to be held in Christchurch, New Zealand, 2007, on the development of an agreement within the framework of the UNESCO Initiative "Astronomy and World Heritage" and Initiative "Starlight", with a view to define a concept of "Starlight Reserve" in order to nominate properties which can contribute by its exceptional night landscape to astronomical researches world-wide.

Additional Resolution of the Steering Committee and the Scientific Committee

Having closed the Conference, and having adopted the "Declaration on the Defence of the Night Sky and the Right to Starlight", in view of the importance of the agreements reached, provisions need to be made for the future. Continuity of the work and of the co-operation already achieved is of vital importance and, to consolidate the results achieved thus far, it is appropriate and necessary to follow up and implement the principles of the Declaration and the recommendations for the Action Plan. To this end, the following decisions are adopted:

1. To create a Steering Committee to monitor the Declaration and its Action Plan (Starlight Initiative), made up of the international agencies and institutions represented on the Conference Organisation Committee, with the addition of representatives of World Tourism Organization, European Landscape Convention, International Astronomical Union, Ramsar Convention, UNEP Convention on Migratory Species, Secretariat of the Convention on Biological Diversity, Spanish National Commission for UNESCO, as well as of any initiatives and organisations related with the different subjects, competences, and disciplines that have an impact on the protection of the night sky that may be required, once the Committee has decided to do so.
2. The Starlight Initiative Steering Committee shall ensure the dissemination, promotion, and circulation of the Declaration and its Action Plan, and its good implementation, following the recommendations of the Scientific Committee and to engage in all and any kind of activities that guarantee its continuity.

3. The Steering Committee is charged of the dissemination and follow-up of the Starlight Conference agreements and it would take on the responsibility to present the Declaration to and disseminate among the main stakeholders, including governments, local authorities, scientific institutions, dark sky initiatives, and organisations involved in environmental protection, defence of cultural diversity, and promotion of sustainable development.
4. The Scientific Committee shall also propose drafting reports, conducting studies, campaigns, co-operation proposals, initiatives, and actions aimed at protecting the skies and enhancing their value, particularly contributing to the fulfilment of the objectives outlined in the Declaration.
5. Among the specific initiatives arisen from the Starlight Conference, which will be approached by the works to be developed by the Scientific and Steering Committees, there are:

    - The establishment of a partnership with the Sustainable Energy Europe Campaign and development of a joint initiative, with the collaboration of European Renewable Energy Council, aiming to develop actions approaching night sky defence and its relation with the promotion of energy saving, the efficient use of energy and renewable energies.
    - Development of a cooperation agreement between the Starlight Initiative and the UNESCO World Heritage Centre through its thematic initiative "Astronomy and World Heritage", that would also include the start of international consultations aimed to develop the "Starlight Reserves" concept.
    - To refer the Declaration to the European Parliament and the European Commission in order to disseminate its principles and, if appropriate, adopt them at the most pertinent level, reminding that clear sky defence is an important component of the fight against climate change.
    - To work jointly with the World Tourism Organization and ITR in order to promote awareness and knowledge related with night sky as a resource to put into value, supporting the development of new responsible destinations and tourist products based on star observation and night sky resources.
    - To strengthen cooperation and mutual support with the initiatives and organisations involved in dark sky conservation, particularly with IDA (International Dark Sky Association).
    - To work jointly with the European Landscape Convention to implement the new dimension of night landscape within the Convention.
    - To develop new ways of cooperation with organisations involved in culture promotion, in particular Unión Latina and the European Society for Astronomy in Culture, to put into value the cultural heritage related with the observation of the firmament.
    - To work jointly with the International Commission on Illumination (CIE) in order to promote the intelligent use of lighting in all exterior applications. This to be with the aim of minimising both the use of energy and the spread of obtrusive light into the natural environment, particularly that upwards into the sky.

StarLight 2007

Appendix 2

Organizations Committed to Reducing Light Pollution

For up-to-date contact details of organizations across the world committed to countering light pollution, the best source is the IDA website. The organizations listed there should be able to give further information on other local groups in their regions. See

www.darksky.org/index.php?option=com_content&view=article&id=476#Europe
www.darksky.org/index.php?option=com_content&view=article&id=435

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

Appendix 3

Starry Starry Night

In 1993, the British Astronomical Association's Campaign for Dark Skies (CfDS) joined forces with the Council for the Protection of Rural England (CPRE) to produce the widely distributed and much quoted booklet *Starry Starry Night*, extensively revised in 2010. Its contents may be of use to anyone seeking to combat both urban and rural light waste, and the bulk of its text is reproduced here.

Human beings have long looked up in awe, on cloudless nights, at the star-strewn heavens. What did our distant ancestors make of it all? They drew the stars into the framework of their lives by creating constellations, fitting them to their beliefs and myths. They marveled at the ghostly river of light which is the Milky Way, our own galaxy of 200 billion stars seen from within, arching across the sky. The stars, the moving planets, and ephemeral events such as aurorae, comets and meteors, all these have inspired religious beliefs, poetry, music and scientific enquiry. The mysterious and unreachable vault of the heavens has been a primary stimulus to the human faculties of wonder and discovery.

For countless years, all this has been ours on every clear night. But during the twentieth century, the glory of the night sky was quietly and gradually taken away from most of the world's people by wasted artificial light. This process continues unabated, and at a rapidly accelerating rate. Satellite images of Earth at night show wasted light-energy from every town and city, along roads, and in rural areas. Even in the countryside, poorly aimed, over-bright floodlights and security lamps have stolen the blessed night from humans, and countless other species which have evolved to the rhythm of light and darkness. The day–night cycles, behavior, feeding and mating patterns of bats, birds, glow-worms, moths, and countless other species are disturbed, and millions are killed, by light going where it is not needed.

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

What causes the skyglow that has erased our stars?

The light we see in the night sky is mostly direct spillage from lamps which have simply not been designed for the lighting task: their emissions trespass onto neighboring areas, and into the sky. They will often be too bright, which adds to glare and skyglow. Light travelling upwards is scattered and reflected by ever-present tiny particles and water droplets in the air, even on the clearest nights. The result is a baleful glow in the night sky, now seen from nearly everywhere in the UK. The constellations, aurorae, meteors and the Zodiacal Light, the faint reflection from billions of dust particles in the plane of the Solar System, are now things of the past for many of us.

There is no doubt that the spread of public lighting since the mid-1800s has brought great benefits. The quality and efficiency of lamps are continually improved, but the 'poor relation' in lighting design is directionality. What the Victorians saw as a blessing has become an environmental blight. Glare, over-lighting and skyglow have tainted the night. Light intrusion into others' premises is now a major cause of complaints to environmental health officers, and research suggests it is damaging to health. The Clean Neighbourhoods and Environment Act 2005 gives local authorities powers to address intrusive light nuisance: but the night sky itself still has no real protection in law.

The stars continue to disappear behind the veil of wasted light, over great cities and smaller towns. Bedrooms are filled with light even with curtains closed. Aggressive 500 W floodlights turn neighbor against neighbor in both town and countryside, ousting the traditional more modest and welcoming porch light. It is an interesting fact that Britain's brightest lighthouse, the Longstone on the Farne Islands, has a 1,000 W source, yet many of us, even those who pay lip service to protecting the environment, use half this amount to light our gardens and drives. Another interesting fact: a 100 W bulb left on all night for 1 year releases a quarter of a ton of carbon dioxide, the major greenhouse gas, from the burning of the fossil fuel used to power it.

Little protest is made about wasted light. Is light pollution merely the uncomfortable cost of progress? Unlike many other forms of pollution, light pollution is reversible. Lights can be shielded or replaced with more appropriate designs, and wattages can be adjusted appropriately. In the words of the Institution of Lighting Engineers: "Light pollution, whether it keeps you awake through a bedroom window or impedes your view of the night sky, is a form of pollution and could be substantially reduced without detriment to the lighting task."

Can we regain our heritage above? Yes. Visit the websites listed on www.britastro.org/dark-skies

Types of Lighting

The earliest practical lights were incandescent tungsten bulbs, still used commonly for domestic purposes. The next development in street lighting was mercury-vapor discharge lamps, which give a blue-white light, but are low efficiency and fairly short life.

Many of the glary, over-powered "security" lamps sold nowadays are of the tungsten-halogen type, very inefficient and short-lived. Then came low-pressure sodium (SOX), the strong orange light beneath which colors are indistinguishable. It is the most energy-efficient lighting and the lamps have a long life.

High-pressure sodium (SON) started to replace SOX in the late 1970s. The SON lamps are much smaller than SOX, which can be nearly a metre long. SON can therefore be more easily enclosed in a reflector that directs the light where it is needed. SON energy efficiency is not as good as SOX but the life is even better.

Today there is a move towards smaller lamps and white light, with better color rendition, though the lifetime may be shorter. Light-emitting diodes (LEDs) are beginning to appear above our streets.

Making a Difference

Here are some tips:

- Talk to people about the skyglow issue, stressing energy and money wasted. What would they think if water mains leaked every few meters?
- The CfDS does not want to switch off any necessary light; its motto is "the right amount of light, directed where needed."
- Are your local media up to date with the skyglow issue? Do they include skyglow in their environmental reporting?
- Ask neighbors about lighting plans and tell them why you enjoy the night sky.
- Politely approach owners of obtrusive lights: they may not know they are causing a problem. Experience shows that most offenders will take some remedial action.
- Write to local councilors, council lighting/highway engineers, MPs, MEPs, sports clubs etc., to ask about their views and lighting policies.
- If new, less glary lighting is perceived by some to be dimmer, make sure that they understand the efficiency of modern, better-directed lamps. Not seeing the glare is a good thing. Set a good example by not using over-bright and glary exterior lights on your own premises.
- We are told that the climate and the environment in general are under threat from energy waste. Ensure that debate in your area recognizes the contribution that light spillage makes to these problems. Remember that 100-W bulb?
- If you or any group you belong to has a website, link to the Campaign for Dark Skies on www.britastro.org/dark-skies
- Try to forestall poor lighting schemes by studying planning applications and making sure your council has lighting clauses in its planning and environmental strategies. Help CfDS directly by subscribing to its newsletter, donating to its fighting fund, becoming a local officer or distributing its literature.

Remember: 'broadsides,' carping criticism and baldly accusing someone of being a polluter are counterproductive strategies. We can reclaim the night sky

through reasoned argument and strength in numbers. Nothing positive comes from light pollution. Everyone wins if it is reduced.

The British Astronomical Association's Campaign for Dark Skies works to ensure star-quality lighting in the UK. Its network of local officers publicizes the problem, praises good practice and strives to turn poor lighting schemes into more acceptable ones.

Appendix 4

The Future of Street Lighting – A Professional's View

Tom Webster is an influential British lighting professional and ILP member. He has taken a great interest in the environmental impacts of lighting, and has summarized, especially for this book, his views on the future of street lighting into the next three decades.

He writes:

It is impossible to look to the future of street lighting without a glance into the past. When the first UK public lighting was installed in Pall Mall, London, in 1807, people were awed by the result. It was seen as "good", and as with the other scientific discoveries of the nineteenth century it was obvious that "more" would be better. This attitude prevailed through most of the ensuing century, and indeed, I remember frequently coming across it when visiting lighting engineers for the first time several decades ago. One engineer's comments in particular are worth quoting: "How can I entertain installing your fancy street lights when there are still areas in my authority that still have no lighting at all?"

It was important to him to install as much cheap (and cheap to run, i.e., low-pressure sodium) lighting as possible.

However, attitudes change. With the end of the twentieth century, as a civilization, we were beginning to realize that rampant technology growth was probably harming our environment, and forecasters were realizing that our contemporary attitudes were unsustainable. This was certainly true among lighting professionals as well. Light pollution was being brought to the industry's awareness by dark-sky campaigners in the early 1990s, and Dr John Mason of the BAA wrote a definitive paper in 1991. For much of that decade the issue was largely seen as an issue for astronomers and a non-issue for nearly everyone else. However, by the end of the century most lighting engineers had come to realize that change was on the horizon,

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

that a paradigm shift in attitude would become necessary. But how to tackle the problems?

Once attitudes change it usually does not take long for technology and ingenuity to propose solutions, and the first decade of the new century demonstrated this. More recently the added impetus of global energy prices and global recession has also added weight to the shift we are now seeing in the discipline of street lighting. The paradigm has shifted from "supply lighting wherever there is none" to "supply lighting where and when needed in appropriate quantities."

However, just because the paradigm has shifted does not mean that the problem has gone away. Far from it. Technology is providing solutions, but these need to be applied and evaluated. So what are the issues and how will they be tackled?

The "where and when needed…" paradigm has three angles to it. Where? This is being tackled with increasingly sophisticated optical systems, from pioneering reflectors used by some companies in the last two decades to the precise lighting made possible by modern LED sources. The "when" angle is being tackled by increasingly sophisticated control choices that have moved from the basic on/off options of old-fashioned photoelectric cells to the infinitely variable possibilities of remote monitoring systems. With these modern systems it has become possible to adjust the amount of light emitted at any point during the night right down to individual street lights via simple Internet-borne command protocols. But where will these lead?

To answer this we need to look at the reasons for the lighting in the first place. Essentially these are twofold, amenity and safety. From an amenity perspective it means that the lighting can become varied in our city centers to provide the public with variety, visual stimulation and the ability to relate to their surroundings in an upbeat and positive manner. The value of the 'night-time pound' should not be underestimated and the prevalence of visually spectacular lighting is likely to increase as more and more of our urban centers strive to tap into the economic benefits of a 24-h society. However, elsewhere the safety benefits are becoming increasingly eroded both through a better understanding of what works and why, and through alternative safety measures that are becoming more predominant.

For example, the brakes of a modern car will stop a car in a significantly shorter distance than those of, say, a 1960s car. Therefore the need to have a street lit that far ahead has become reduced (to mention nothing of the increased efficiency of modern headlights). What this will mean is that over the next decade we will see an increasing number of lighting installations either permanently removed or switching over to the more controllable types mentioned before. Conventional high intensity discharge (HID) sources such as high-pressure sodium and metal halide will not give up without a struggle, but will become increasingly obsolete against newer more controllable sources such as LEDs. By 30 years hence they will either have become phased out or will be on the short list for removal come the next capital expenditure round for any given authority.

In 30 years' time I foresee the major problem facing dark skies campaigners regarding lighting in the streets as being from car headlights, and indeed, campaigners will be pushing for wide-scale adoption of night vision devices and radar

systems for cars, especially if the move towards the 24-h society in our city centers continues.

There will be other emergent technologies but none as directly significant to lighting per se as the ‘double whammy’ of infinite switchability offered by Internet-borne remote monitoring and flexibility (including instant ‘on/off-ability’) of LEDs. Technologies to watch for in the future will focus on the ability to do without lighting altogether, such as proximity radar systems, whether offered by electromagnetic including non-visible light or acoustic means and other smart systems to do with moving people about from the 24-h cities to and from their dwelling places.

What about the amateur astronomer? The next decade will probably be very positive as we see increasing numbers of switch-offs, mostly as a response to the austere social environment we are currently facing. However, in the next 20–30 years we may well face a night-time environment where major city centers are emitting significantly more light than now in the later parts of the night and suburbia that is almost completely dark, except for light-emitting traffic. The Campaign for Dark Skies will not be over anytime soon.

Appendix 5

Recommendations for Good Light Control

ILP Guidance Notes

The Institution of Lighting Professionals (see Bibliography) has produced the following guidelines for good lighting control (reproduced with permission). It should be noted that its recommendations (Table 1) for permitted upward light do not necessarily concur with those of dark-sky organizations, who see no reason to allow upward light anywhere.

Guidance Notes for the Reduction of Light Pollution

All living things adjust their behavior according to natural light. Man's invention of artificial light has done much to safeguard and enhance our night-time environment but, if not properly controlled, obtrusive light (commonly referred to as light pollution) can present serious physiological and ecological problems. Light pollution, whether it keeps you awake through a bedroom window or impedes your view of the night sky, is a form of pollution and could be substantially reduced without detriment to the lighting task.

Skyglow, the brightening of the night sky above our towns and cities; glare, the uncomfortable brightness of a light source when viewed against a dark background; and light intrusion, the spilling of light across property boundaries, are all forms of obtrusive light. This is not only a nuisance, it wastes electricity and thereby large sums of money, but more importantly it helps destroy Earth's finite energy resources, resulting in unnecessary emissions of greenhouse gases.

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

Listed below are some easy ways to reduce the problems of unnecessary, obtrusive light:

[Al] Do not over-light. This is a major cause of light pollution and is a waste of money. There are published standards for most lighting tasks.

[A2] Switch off lights when not required for safety, security or enhancement of the night-time scene. In this respect one can introduce the concept of a curfew, i.e. a period in which more restrictive controls are applied to obtrusive light. In all new developments there is scope for Local Planning Authorities (LPAs) to impose conditions relating to curfew hours in determining planning applications. For instance the LPA may determine that non-essential lighting, such as advertising and decorative floodlighting, should be switched off between 23.00 h and dawn. In the case of new non-residential developments LPAs are encouraged to impose such curfews. The attachment of domestic security and decorative lighting to residential buildings often does not require planning permission. However, as the floodlights are operational throughout the night, it is considered that the after curfew levels of lighting control shown in Table 1 should be used at all times.

[A3] Use specifically designed lighting equipment that minimizes the upward spread of light near to, or above the horizontal. Care should be taken when selecting luminaires to ensure that the units chosen will reduce spill light and glare to a minimum. The use of luminaires with double-asymmetric beams designed so that the front glazing is kept at, or near parallel to, the surface being lit will assist in the reduction of glare, provided the units are correctly aimed. Similarly, modern well-controlled projector type luminaires, which can be aimed very precisely, can give an excellent cut-off beyond the lit area so reducing spill light and glare.

[A4] Keep glare to a minimum by ensuring that the main beam angle of all lights directed towards any potential observer is kept below 70°. Higher mounting heights allow lower main beam angles, which can assist in reducing glare. In areas with low ambient lighting levels, glare can be very obtrusive and extra care should be taken when positioning and aiming lighting equipment. When lighting vertical structures such as advertising signs, direct light downwards, wherever possible, to illuminate them; not upwards. If there is no alternative to uplighting, then the use of shields, baffles and louvers will help reduce spill light around and over the structure to a minimum.

[A5] For road lighting installations, light near to and above the horizontal should be minimised to reduce glare and visual intrusion (Note ULRs in Table 1). The use of full horizontal cut-off luminaires installed at 0° uplift will minimise visual intrusion within the landscape as well as upward light. However, in many urban locations, luminaires fitted with a shallow bowl providing good control of light near to and above the horizontal can provide a satisfactory solution whilst maximising the spacing of the luminaires.

Table 1 Obtrusive light limitations for exterior lighting installations

Environmental zone	Skyglow ULR (max.%)	Light into windows E_v [lux] (1)		Source intensity I [kcd] (2)		Building luminance before curfew (3)	
		Before Curfew	After Curfew	Before Curfew	After Curfew	Average L[cd/m^2]	Maximum L[cd/m^2]
E1	0	2	1[a]	0	0	0	0
E2	2.5	5	1	20	0.5	5	10
E3	5.0	10	2	30	1.0	10	60
E4	15.0	25	5	30	2.5	25	150

Notes

LIGHT INTO WINDOWS – These values are suggested maximums and need to take account of existing light trespass at the point of measurement.

SOURCE INTENSITY – This applies to each source in the potentially obtrusive direction, outside of the area being lit. The figures given are for general guidance only and for some large sports lighting applications with limited mounting heights, may be difficult to achieve. If the aforementioned recommendations are followed then it should be possible to further lower these figures.

BUILDING LUMINANCE – This should be limited to avoid over lighting, and relate to the general district brightness. In this reference building luminance is applicable to buildings directly illuminated as a night-time feature as against the illumination of a building caused by spill light from adjacent floodlights or floodlights fixed to the building but used to light an adjacent area.

Where *ULR* Upward Light Ratio of the Installation and is the maximum permitted percentage of luminaire flux for the total installation that goes directly into the sky (formerly UWLR)

Ev = Vertical Illuminance in Lux normal to glazing

I = Light Intensity in candelas

L = Luminance in candelas per square meter

[a]Acceptable from public road lighting installations ONLY

Environmental Zones

It is recommended that the Local Planning Authority as part of their Development Plan specify the following environmental zones for exterior lighting control.

Category	Examples
E1	Intrinsically dark areas: national parks, areas of outstanding natural beauty, etc.
E2	Low district brightness areas: rural or small village locations
E3	Medium district brightness areas: small town centers or urban locations
E4	High district brightness areas: Town/city centers with high levels of night-time activity

Where an area to be lit lies on the boundary of two zones or can be observed from another zone, the obtrusive light limitation values used should be those applicable to the most rigorous zone.

These limitations may be supplemented by a Local Planning Authority's own planning guidance for exterior lighting installations and you are therefore recommended to check with the Local Planning Authority before designing or installing any exterior lighting.

IDA's Good Neighbor Practical Guide

Many of us have experienced this scenario: your neighbors have just installed a new spot light on their property. It has a dusk to dawn sensor on it and they are very proud that they are going to be safe now that they have this light. Unfortunately, it's lighting up your yard and/or shining into your home, and you don't want that. How do you talk to your neighbor about this situation? Following are the steps approved by the International Dark-Sky Association to educate your neighbor, and by extension your community, about the value of dark sky friendly lighting.

#1. They probably don't realize the light is bothersome. Always approach people in a friendly, non-threatening way.

- Don't argue.
- Be tactful and understanding.
- Don't dismiss their need to feel safe.

#2. Do your homework and be prepared to address the real issues. No one said this would be easy.

- Know the local costs of electricity (cents per KWH).
- Know if there is a local lighting control ordinance, and if so, what are the details.
- Research quality security lighting in your area by using the IDA FSA lighting list.

#3. Don't hesitate to ask them for their advice/opinion in solving the problem. Good will goes a long way.
#4. Use IDA sound bites whenever you can.

- Dark sky friendly lighting does not mean dark ground.
- If they don't identify with astronomy talk about the cost/energy savings of quality lighting.
- Agree with them that safety is important and dark sky friendly lighting is safer.
- Brighter does not mean safer.

#5. Print off free materials from the IDA Education tab and present this information to your neighbor. If there are further questions, call us, or email us, together. We will answer!
#6. A lawsuit is never a good option.

- Lawsuits are expensive for everyone.
- It creates bad feelings between families/neighbors, and you do live in the area.
- Moving is equally expensive.

Safety Issue

The IDA believes that outdoor lighting should provide real security, not just the illusion of safety using bad lighting. Dark sky friendly lighting shines the light on the ground where it is needed, not into the sky where it is not. It uses a lesser wattage lamp, which decreases harsh shadows for the "bad guys" to hide in. Effective lighting produces uniform coverage of the area; bad lighting can attract criminals by giving them a place to hide.

Safety includes seeing where you are walking and improving your night time driving experience. Fully shielded lighting provides the necessary illumination to see your surroundings, but without the glare to harm your night vision.

Studies have indicated that there is no conclusive correlation between night lighting and crime. Most property crime is still committed during the day, or inside lit buildings. Smart lighting directs the light where you need it, so you don't have to choose between security and the natural night sky.

Dark sky friendly lighting is capable of using a lesser wattage lamp than traditional lighting. Why is this? Because by shielding the light (no light above the 90° angle), you direct all the light downward, where it is needed. By directing the light you are not wasting energy lighting the sky above you, and hoping for some of it to "fall" to the ground.

Further energy savers include using timers, dimmers, and motion sensors on outdoor lighting. These features allow you to use the light when you need it, not just in case you need it. By each of us decreasing our carbon footprint for outdoor lighting we can save the equivalent of 600 million gallons of gasoline every year.

The Cost Issue

In terms of cost, in today's economy every little bit helps! Dark sky friendly lighting fixtures cost no more than traditional outdoor lighting fixtures. The big difference is you can use less power to run these fixtures than traditional lamps. Your cost savings on your utility bill will pay for the fixture within the year. By shielding the fixture, meaning no light above the 90° angle, a lesser wattage lamp can now be used because you don't have to light the night as well as your steps. Why pay for light that is not being used? Wasted light at night in the United States alone costs $1.74 billion annually.

The Wildlife Issue

Scientists and researchers are only now beginning to understand the long term effects of too much artificial light at night on all species. As humans expand into more rural areas, our light pollution produces a "continual state of twilight" on the habitats around us. This twilight affects mammals, birds, amphibians, reptiles, and insects. These ill-effects include reduced foraging for food, decreases in reproduction, more predation from daytime creatures, and reduction in natural navigation abilities. This is all preventable!

Sample Letter to Neighbor or Business

Dear XXXXX

Allow me to introduce myself, I am your neighbor (insert name) and I would love to talk to you about good outdoor lighting. I have noticed that you have installed outdoor lights on your property, and I applaud your desire to help improve our neighborhood.

At this time your lights are a bit too bright and they are shining in (pick areas as they apply: our bedroom window, the backyard, into our house etc.), and interferes with our (sleep, hobbies, view of the sky, etc.). I'm sure you weren't aware of this and I wanted to bring it to your attention as soon as possible to avoid any misunderstanding. Let me be clear. I am not asking you to remove the lights, but perhaps they can be re-directed onto the ground where they will do the most good. In addition, we could work together to shield the lights so that they are even more effective. Shielding a lamp usually requires a lesser wattage bulb, which is a big money saver within just a year's time. Who couldn't use a few money saving tips these days? Shielding reduces glare, which can be blinding and produces less harsh shadows where the "bad guys" can hide. Dark sky friendly lighting provides real security, not just an illusion.

There are other ways to save money and still be safe. When lights have motion sensors, they provide an alert if someone is in your yard after dark and they save you money by keeping the lights off when they are not needed. Timers are another money saver because they can turn off your lights when you will not be using the yard, for instance when you retire for the night.

Thank you so much for your time and understanding. I would love to talk with you further about the advantages to using dark sky friendly lighting and how it benefits your safety, your budget, and the night sky.

Sincerely,
Your Neighbor

The Cranborne Chase and West Wiltshire Downs Area of Outstanding Natural Beauty Position Statement on Light Pollution (2008)

The Cranborne Chase and West Wiltshire Downs AONB derives much of its beauty from its qualities of tranquility, remoteness and cultural heritage. Light pollution has the potential to erode and destroy that tranquility and sense of remoteness.

It is therefore considered appropriate that all artificial external lighting within its borders or within the setting of the AONB should be muted, screened, and the minimum required. To accord with this aim, no external lights should be erected or installed in or within the setting of the AONB unless:

1. They can be shown to be essential for security and safety, and the minimum necessary to achieve it;
2. They are directed downwards and designed or shielded to prevent upward, sideways and outward spillage;
3. They give a light whose color and intensity are appropriate for the wider setting;
4. They do not highlight a structure or feature that would have an adverse visual impact on the surrounding landscape; and
5. They utilize the most energy- and pollution-efficient equipment that is reasonably available.

In order to meet these aims where existing lighting is identified as having an adverse effect on the character of the AONB, the AONB Partnership will encourage and facilitate the removal or modification of the lighting units. Modifying and installing external lighting that meets the above criteria will help to ensure that the AONB's special character and attractive environment will not be spoiled by skyglow or intrusive light.

Appendix 6

Extracts from Articles on the Legal Aspect of Light Pollution

(Reproduced With Permission)

In her article *Light Pollution: A Review of the Law (Journal of Planning and Environment Law,* January 1998), lawyer Penny Jewkes wrote that: There are several parallels to be drawn between light pollution and noise, which occupied a similarly uncertain territory prior to 1960, when the Noise Abatement Act reflected various bylaws used by local authorities to deal with local noise problems. However, it was not until the Control of Pollution Act 1974 that effective and comprehensive controls were introduced. Light has the potential to cause distress and is an equally insidious pollutant. Noise and light are both intangible and ephemeral, yet susceptible to measurement; their detrimental effects are relatively easily avoided or stopped and both are closely associated with the development pressures of post-industrial societies. It is the perception of the relative degree, frequency and effect of the problem which causes noise pollution to be more regulated than light pollution, rather than any technological differences.

There is significant capacity within the planning system to influence the design and installation of lighting schemes, but it has a limited ability to control the problems caused by poor lighting which is unrelated to new development. Development plans and supplementary planning guidance may regulate the lighting considerations arising out of any new proposals, but the development control process is constrained by the fundamental problem that many of the lighting installations that cause this form of pollution fall outside its statutory scope.

Planning permission is usually required for the carrying out of any 'development' of land. As is well known, this can take two forms, namely 'the carrying out

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

of buildings, engineering, mining or other operations, in, on, over or under land.' It is a question of fact in each case whether a lighting installation amounts to a building or an engineering operation. These terms are given their ordinary meaning although the courts have said that engineering operations are usually those undertaken by engineers, which would include specialist lighting engineers. Large scale installations, such as the lighting of a football stadium or public tennis courts, are clearly a form of development which comes within the statutory definition. More difficult, however, is the smaller scale lighting installation, which is probably outside planning control unless it materially affects the external appearance of a building. This qualification has to be interpreted in the light of the individual case.

The impact of lighting on amenity and on the environment are material considerations in the decision-making process… As a general rule, local planning authorities are not encouraged to duplicate controls imposed by other statutory bodies (such as the Environment Agency). But environmental considerations are material, and, since light pollution is not specifically controlled under any other legislation, the problem of duplication of control does not arise. The protection of a group of individual interests, such as disturbance to neighbors, is an aspect of the public interest and capable of being a planning consideration.

Light is not specifically included in the list of potential nuisances (*Author's note: this was written before the CNE Act lighting clause mentioned in Chap.* 3 *came into effect*). Nevertheless, some local authorities have served abatement notices under Section 80 in respect of light nuisances. It is debatable whether such a course would survive a challenge on appeal, although it might be possible to argue, in appropriate circumstances, that intense building luminance amounted to 'premises in such a state as to be a nuisance.'

The common law action for nuisance is the most common method of asserting an environmental claim. Nuisance takes two forms: public and private. a private nuisance arises from a substantial interference with an individual's use and enjoyment of his property, and an action can only be pursued by the individual whose rights have been affected…. A public nuisance is one 'which materially affects the reasonable comfort and convenience of a class of Her Majesty's subjects.' This tort shares many of the characteristics of private nuisance. However, a public nuisance is a criminal offence and the action may be brought by the Attorney General (or the Local Authority). An individual may also bring proceedings if he has suffered some special damage over and above that suffered by the general public. Where floodlights from a sports stadium affect a large number of people living in an area, and have a particularly detrimental effect on adjacent landowners, the complainants may have an action in private and public nuisance. This type of action, in which excessive lighting is alleged, requires the courts to effect a delicate balancing exercise between neighbours' competing uses of land. The court will take numerous factors into account, such as the locality where the complaint has arisen, how often the activity occurs, whether one neighbour is more sensitive than normal and whether the other party has a good reason for carrying out the activity complained of.

Conclusion

Light pollution is a relatively newly identified environmental problem and in some of its manifestations it may appear to be a relatively insignificant issue. But insignificant to whom?

A person who is unable to sleep because of his neighbor's security light may not regard this as a minor problem. He may be perplexed by the logic which says that if his neighbor's dog keeps him awake at night the local authority environmental health officer has powers to intervene on his behalf, but he cannot do so if the insomnia is caused by glaring lights. A sensitively designed development may be absorbed into a rural scene without detriment to visual amenity and be acceptable to local people. The position might be quite different when they see it lit up at night. We want our children to inherit a planet rich with diverse species and plantlife; is it any less important that they should be able to see the Milky Way or the tail of the Hale-Bopp comet? Does it make any difference whether the survival of a rare insect is jeopardized by a light source or by a pesticide? These are some of the many questions which the problem of light pollution raises and which are only in part addressed by the existing regulations."

In his article "And God Divided the Light from the Darkness" – Has Humanity Mixed Them Up Again? (*Environmental Law and Management*, January 1997), law lecturer Martin Morgan-Taylor wrote: "The increase in national and local authority maintained night lighting is arguably treating the symptoms of the societal disease which manifests itself as crime: for example, increasing lighting because there is an increase in crime. The money spent on reducing the fear of crime, and on giving the impression that money is being spent on run-down areas, could be put to much better use by fighting crime at its roots…. The second matter usually cited to defend the general increase in lighting is safety. It must be accepted that without lighting, the world would not be safe at night. However, a balance is what is needed, not an absolute flood of lighting for lighting's sake…. the American 'Green Lights' program, launched in 1993, is a government backed movement to replace light fittings both public and commercial with fittings which are more economical and less ecologically harmful. The aim is to cut energy bills for participants, and reduce global environmental impact. The Environmental Protection Agency estimates that if 'green lights' were implemented on all participants' land, $16 billion would be saved. This equates to 12% of U.S. utility carbon/sulphur/nitrogen dioxide emissions.

"It is proposed that there are solutions to the lighting problem. Firstly, there should be some form of legislation which restricts power consumption and output of domestic exterior floodlighting. There is no positive gain to be had by installing a 500 W light in a small back yard, but there are disadvantages, both to the environment and to neighbours. All light fittings should be properly designed, perhaps to a BS standard, so that they may point straight down and still permit the functioning of a trigger mechanism. Instructions for their installation should counsel the installer to angle the light sensibly, so that a burglar may be seen by a passer-by

who will not be dazzled, and so as not to interfere with neighbours. Environmental health departments should be granted the authority to order the repositioning of poorly placed lights that interfere with neighbours or pose a risk to road traffic. Should a person not comply, then local authorities should have the power to remove the light fitting, or where the offender has been malicious or uncompliant, to prosecute… maintaining safe levels of night-time lighting, with the intention of reducing environmental harm…such a policy will reduce the emission of greenhouse gases and also help protect the environment. It is argued that this time has now come."

Appendix 7

Some Lighting Myths (Reproduced by kind permission of Dr. David Crawford, IDA)

1. THE MORE LIGHT THE BETTER: "The more light the better" is the same type of reasoning as saying the more salt on your food the better, or the more fertilizer the better, or the more medicine the better. Obviously, there comes a point where you can have too much of a good thing. Eventually, it becomes wasteful or even harmful. Night-time lighting is that way. We need well-lit streets, security lighting, and parking lot lighting. However, we do not need glare, clutter, confusion, light trespass, light pollution, and energy waste. Excessively bright, numerous, unshielded lights cause all of these things.

   The amount of light you need depends upon the task. For example, you use low wattage colored bulbs for Christmas tree lights, and perhaps a 60 W bulb for a porch light. If more light is better, why are night lights in a bedroom dim instead of bright? The next time you are at an airport at night look at the brightness of the taxi lights (blue color) or the runway lights (white color). They are relatively dim so as to not harm the pilot's night vision and cause confusion. Even the rotating airport beacon is not especially bright. The strobe lights on tall chimneys and radio towers are of low wattage, yet they are visible for miles. Those who claim "the more light the better" often are salespeople or manufacturers who pander to people's misconceptions to make a quick sale rather than educate their customers about truly effective and environmentally responsible lighting.
2. LIGHT POLLUTION ONLY AFFECTS ASTRONOMERS: Light pollution affects all of us. It robs the professional astronomer of his or her livelihood and hinders the amateur's enjoyment of their hobby. It deprives us all of one of nature's grandest wonders – the night sky. Many persons who claim this is of no importance have never gone far out of town to see what they are missing. Those who grow up in an urban environment may never see the Milky Way. How can someone miss something he has never seen? The loss of this part of nature desensitizes

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

us to other insults upon the environment. This is like saying the loss of a virgin forest is of no concern because most people won't get to see it anyway, and there are plenty of trees for lumber. The loss of wildflowers, polar bears, wolves, whales, and other threatened species, to be honest, won't affect the average person. Their loss only directly impacts biologists, or those more in tune with the natural environment than in the environment we humans create. After all, humans have done very well without mammoths, mastodons, and passenger pigeons. However, no one supports the extinction of magnificent animals. Why should we permit the loss of our skies? Not only does light pollution dim the stars for the astronomer, but it dims them for all persons. Everyone has a right to the stars.

Light pollution takes away one of our most ancient heritages and it represents visible destruction of the environment in several ways: the dome of light hanging over most cities blots out the stars; electricity is generated and wasted to light the night sky – light needs to be on the ground not up in the sky; the wasted electricity represents wasteful burning of coal, oil, and natural gas; the by-products of these wasteful burnings show up as acid rain, smoke, and carbon dioxide emission; strip mining and underground mines ravish the land to produce the coal for the wasteful burnings; runoffs from this mining pollutes rivers and streams. Thus, light pollution does far more than inconvenience a few astronomers. It is a most harmful assault upon our environment. It affects us all, and all of us ought to be concerned about it.

3. JUST GO OUT OF TOWN AWAY FROM THE LIGHTS: This is equivalent to saying why worry about the loss of trees and flowers in our cities. Why have urban parks? Just go out of town to see some grass, flowers, or trees. It shouldn't be necessary to go out of town to see these. If we can't have enough sense to plant trees, shrubs, and flowers all around our cities, we can at least have enough sense to plan for parks and preserve those green areas left. Why not have the same attitude toward dark skies? We are not asking people to turn off their lights. We are asking them to shield the lights, use proper wattage for the task, and turn off unneeded lights. In any event, it is no simple task to get away from the lights. Urban sky glow, the dome of light hanging over all cities of any substantial size, extends for miles and miles. For example, it easy to see the sky glow of Phoenix, Arizona, from more than 100 miles away. The sky glow from Los Angeles, California, is visible from an airplane 200 miles away. How many dark spots are left in the urban corridor in the North-eastern part of the United States? Even in the most remote portions of North America, there are dusk-to-dawn lights blaring into the darkness. The light from even one of these causes significant light trespass a mile or more away. I challenge anyone reading this to find a mountain top or plateau in the continental United States where there is no trace of light pollution visible somewhere on the horizon.
4. IT'S TOO LATE TO DO ANYTHING ABOUT LIGHT POLLUTION: THERE ARE TOO MANY LIGHTS: This is a frequent response when I ask people why they are not more active in the light pollution struggle. It's a tough response to adequately address. Yes, the problem is enormous, growing in many areas, and

very difficult to grasp fully. This doesn't mean it isn't worthy of effort. We have barely begun to fight. Just because we have a very big problem on our hands and presently few resources to bring to bear, doesn't mean we can't ultimately win. It's way too early in the struggle to say it's impossible to do anything about light pollution. Only recently has a small fraction of the public and astronomical community awakened to the problem. Only recently have we realized there are solutions to most lighting difficulties. There are now excellent fixtures available for all lighting needs. This is one of those few problems whose solution is eminently sensible, available, and which saves money in both the short term and the long haul. If you expect to rid a city of its sky glow in the next year, then you will be very disappointed. If you want to get rid of local sources of light trespass, such as a dusk-to dawn light next door or an unshielded street light on the corner, then you have a very good chance of accomplishing your goals with persistent but not obnoxious effort. You also have a reasonable chance for changing laws and instituting proper lighting techniques in your community. Over a long period good lights will replace the bad and the ugly ones. There will be a gradual slowing of the loss of dark skies and then an actual darkening of the sky in some areas. This will not happen quickly but it is possible. It will take incredible amounts of work and determination but it can be done.

5. LOW PRESSURE SODIUM (LPS) CAUSES HEADACHES: This is just one of hundreds of ill-founded rumors about LPS lighting. Low pressure sodium is the most energy efficient lighting available. LPS is favored by professional astronomers because it is an essentially monochromatic light source, more easily filtered out than other light sources. It produces a bright, yellow light to which the eye is very sensitive. Therefore, it is very good for street lights, parking lot lighting, and security lighting. Ask those in San Diego, San Jose, Long Beach, and Glendale, Arizona, where LPS is used extensively. Why isn't it used more often? The answer is complex. Several large lighting manufacturers do not make LPS fixtures or bulbs and campaign against it. It has no color rendition, which bothers many persons, especially when they first see it, and it should not be used for any lighting application that needs good color. LPS fixtures and ballasts are expensive and not readily available, even though LPS use quickly saves money. LPS lighting does not produce headaches any more than any other type of outdoor lighting. In fact, it tends to produce less glare than mercury vapor lights or high pressure sodium (HPS) lights and is thus probably less likely to give headaches. LPS bulbs are no more dangerous to dispose of than any other type of light bulbs. In fact, consider the toxic substances that are found in other bulbs. Mercury vapor lights contain mercury. In the metallic form, mercury is not especially toxic but many of its salts are quite poisonous. HPS bulbs contain metallic sodium just like LPS bulbs; therefore, they have the same disposal problems as the LPS bulbs, mainly the metallic sodium which is highly reactive. If HPS or LPS bulbs are carefully broken under water, the sodium reacts with the water to give sodium hydroxide, everyday lye, the same substance as in drain cleaners. How about all the glass? Well, this is a problem with disposing of any light bulb. Metal halide bulbs contain all sorts of toxic metallic salts. The bottom line is that

the disposal of a large number of light bulbs is an environmental problem no matter what the bulb type.

6. SECURITY LIGHTS PREVENT CRIME: Does outdoor night-time lighting prevent crime? The answer is: nobody knows. In some cases, lighting seems to deter crime and it makes people feel more secure, but in reality they may be just as secure without the lighting. In some cases, lighting probably increases crime because it draws attention to a house or business that would otherwise escape attention. Most crimes, violent and otherwise, take place during the day. After all, criminals need light to do their work, too. A dusk-to dawn light shining all night in a rural area probably is an inducement for robbery and vandalism. A passer-by might not otherwise notice that the farmhouse is even there. An infrared motion-sensor security light which comes on only when someone steps into the beam makes a lot of sense. It is only on when needed, thereby conserving energy. Its sudden illumination serves to frighten away the criminal. These lights are now beginning to replace some of the all-night dusk-to-dawn 175 W mercury vapor lights. This makes good sense from the economic, environmental, and crime prevention points of view. The motion-sensor security lights can cause light pollution and light trespass if too high a wattage spotlight is used, or if they are not aimed down toward the ground. They should also have some shielding. Do street lights, parking lot lights, and security lights prevent crime? Maybe yes, maybe no. If they are overly bright with much glare, they actually make it easier for a criminal to hide in the deep shadows produced by objects in the harsh glary light and encourage crime rather than discourage it. Well-lit streets with even, uniform lighting, low glare, and utilizing fully-shielded fixtures probably have lower vehicle and pedestrian accident rates. How about bright lights in a parking lot? How many people do you know whose car has been broken into during the day, or while directly underneath a light at night? One speaker at a recent lighting symposium recounted how his car was robbed at a local mall. It sat near a store entrance and was directly under a bright light! There are simply no good scientific studies that convincingly show the relationship between lighting and crime. Our cities are far more brightly lit than ever. Yet, the crime rate soars. Maybe lights directly lead to crime. Who knows? One study at a small eastern college showed almost all violent night-time crimes took place in well-lit places. This study, while informative, cannot be generalized to other locales because of the somewhat unique nature of the college and the college town. Crime is a very complex sociological phenomenon controlled by many factors, and it will vary considerably from place to place. My own personal opinion is that crime is little affected by night-time lighting for better or worse. Main arterial streets should be well lit to reduce automobile and pedestrian accidents. Busy malls should have good lighting to reduce accidents and perhaps deter crime. After business hours this lighting can be reduced or even turned off. Security lighting can be at a relatively low level. This saves money, and not much light is needed to find your way to a door or find your way out to your car. Not much light is needed to see a suspicious-looking person loitering around. No matter what the lighting situation, the proper wattage, not overkill, should be used, and all light should come from

full-cut-off, shielded fixtures. Low pressure sodium lighting is ideal for many of these applications because of its very low operating cost.

7. ONLY ASTRONOMERS CARE ABOUT LIGHT POLLUTION (THOSE PERSONS FIGHTING LIGHT POLLUTION ARE JUST CRAZY IDIOTS): Anyone who takes a well-educated and reasoned approach toward environmental or quality of life issues is not a "crazy idiot." We (and many others as well) are concerned about light pollution, light trespass, radio pollution, and space debris. After all, the night sky is part of everyone's environment, enormous amounts of energy are wasted lighting the night sky, radio astronomers have to struggle to find usable portions of the electromagnetic spectrum for their work, and space debris is a rapidly growing problem for spacecraft (and people) in orbit. Why should someone be considered a nut because he or she is concerned about the environment? However, persons involved in environmental causes must carefully define the problem they want to solve, learn the facts, appreciate the legitimate perspective of their opponents, and offer people solutions rather than complaints. This is IDA's philosophy and modus operandi. Light and radio pollution are solvable problems if the facts are properly conveyed to the public. Light pollution is the one form of pollution whose solution immediately saves money. Not just astronomers care about light pollution and light trespass. IDA's Board of Directors consists of a physician, a lawyer, two lighting designers, a city street lighting director, as well as professional and amateur astronomers. Many IDA members are not astronomers or even particularly interested in astronomy. They are concerned about energy conservation, preservation of our environment, and proper night-time outdoor lighting. They include homemakers, scientists, lawyers, pilots, doctors, engineers, retired persons, and so forth. Much of IDA's strongest support comes from professional lighting engineers, lighting suppliers, and lighting manufacturers.

Appendix 8

Advice from IDA and CfDS

IDA's standard letter informs and suggests courses of action:

Dear … ,

Here is an environmental issue you might not have heard of yet: Light Pollution. It is a growing threat to our night-time environment, one that has already seriously harmed astronomers, both amateurs and professionals. We are faced with the distinct possibility that in only a generation or two very few people will be able to have a "live" view of the universe. Urban sky glow will have blotted out the dark sky, just as a lighted room blots out the view of a slide show.

Components of light pollution include:

1. Urban Sky Glow: it is destroying humanity's view of the universe.
2. Glare: blinding us and harming visibility; Glare is never good.
3. Light Trespass: someone's outdoor lights offending us, "trespassing" on our property.
4. Clutter: trashing the night-time environment, and causing confusion as well.
5. Energy Waste: wasted light costs over one billion dollars a year, in the United States alone.

There are solutions to all of these problems. Quality lighting is the key. These solutions preserve the dark skies, improve the quality of the night-time lighting and the night-time environment, and save money as well. It is a Win/Win/Win situation.

Awareness of the problem and of the solutions is needed, of course, but is often lacking, even among lighting professionals. Lack of awareness (rather than resistance) is the main problem in implementing these solutions.

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

You can help. Please do. Here's how:

First, become aware. Insist on quality lighting. Use it yourself. Quality lighting is well shielded (so the light is used, not wasted), uses the right amount of light (not overkill), includes time controls when possible, and includes the use of low pressure sodium (LPS) as the light source when possible. (LPS is the most cost-effective light source, excellent where color rendering is not critical.) Quality light is directed downward where it is needed, not up or sideways where it is wasted and causes glare, light trespass, and bright skies.

Second, a non-profit organization, the International Dark-Sky Association (IDA), is very active in raising awareness of the issues and in pushing for solutions to the problem. The IDA also addresses the related issues of radio interference, space debris, and other environmental threats to our view of the universe. All of these problems adversely affect the general public and seriously threaten the future of frontier astronomical research everywhere on Earth.

(Included are several sheets which discuss this issue in greater detail.) I hope you will take the time to read them, and to think about the issue. The IDA, and all who care about the environment and our quality of life, need your help. Please become aware of wasteful lighting, and do what you can to help.

Sincerely yours,
Etc.

CfDS sends the following advice to people seeking guidance on countering problems caused by stray light:

If writing to your council, and in spreading awareness about sane lighting, you might consider the following options:

1. Find out who is responsible for lighting. If "A" class roads are lit, it is normally the Highways Agency; minor roads and side streets are normally lit by the county or district council. All councils will have a lighting engineer, and (s)he should be following the guidelines of the Institution of Lighting Professionals (ILP), which recommend minimal upward light. All major lighting companies, dozens of local councils, the Institute of Environmental Health Officers, the Campaign to Protect Rural England (CPRE – joint producers with the BAA of the *Starry Starry Night* leaflet), and many other bodies agree with the BAA/CfDS and the ILP that light pollution is a problem to be confronted. Anyone installing glary road lights with upward waste light is simply behind the times and not environmentally aware;
2. Refer your lighting engineer(s) to the ILP, and also to the many lighting firms now producing full-cut-off and semi-cut-off lamps. With the latter, there should still be minimal upward light (what lighting people call Upward Waste Light Ratio [UWLR]).
3. Tell friends and neighbors about light pollution, using CfDS material. An astronomer in a nearby back garden at night is a far more effective security device than any number of 500 W lights! Try to let everybody (local press?) know that the environment above is just as valuable to the human spirit as that below. Get your local environmentalists involved: the CPRE, for example, has produced a "light

pollution charter", and declares itself firmly committed to eradicating local light pollution;

4. Resist arguments such as: *"it's not the lights shining upwards. It's mostly reflection off the ground"* – anyone standing on a hill over a large conurbation can see with their own eyes that it is the lamps which are glowing brightly, not the ground! Or *"cut-off lights are more expensive"* – they may be, but what price the environment? The trend is towards environmentally friendly lighting, and councils with glary lights may well have to replace them with something better in the near future. Why not do it now and save money later? Or *"you need more lights with FCOs as they have to be spaced more closely together"* – no they don't. The local street lights in the CfDS coordinator's area have now been replaced with FCO and SCO designs. The night sky is much improved (which further refutes the ground reflection argument) and they are on exactly the same columns as the old, wasteful lights. The M5 motorway was recently relit with FCOs – four FCOs for every five old, glary lights, so they are actually now further apart. It's column height and the optical reflectors in the lamps which control the light spread, not the distance between them. Or *"lights have got to be bright to defeat crime"* – there is no proof that light and crime are related. Some studies show a reduction in crime where lighting has been introduced or upgraded. Other studies show the opposite, or no change. The vast amount of crime which takes place in broad daylight suggests that ambient light levels do not deter criminals. The best friend of the modern burglar is the sideways-pointing 500-W "security" light, which emits a dazzling glare behind which he can work unseen.

CfDS wishes you success in spreading the message that effective lighting and an attractive natural night-time environment are not mutually exclusive.

Appendix 9

Examples of Governmental Guidelines on Good Lighting Practice

Guidelines issued by national governments for the reduction of light pollution are few; for example, I have been unable to discover any American governmental agency guidelines on good lighting (if any appear, the IDA website will undoubtedly feature them). The first such advice was probably that contained in the document *Lighting in the Countryside – Towards Good Practice* (ISBN 0 11 753391), issued by the British government's Department of the Environment in 1997, in collaboration with the UK Countryside Commission and with input from CfDS, CPRE, ILP and the Royal Fine Arts Commission. Though restricting its brief to rural lighting, this 80-page guide contains advice on all its aspects. In its section on 'Action on Lighting in the Countryside' we read:

> Lighting in itself is not a problem; it only becomes a problem where it is excessive, poorly designed or badly installed. Better use of the planning system to influence lighting proposals; better awareness of the potential adverse impacts of light amongst developers, manufacturers, retailers and the general public; and improved lighting design and landscape design are among the most important ways of tackling issues of overlighting…. For all but the simplest lighting scheme, professional advice whether from the lighting manufacturer or from a qualified lighting engineer/designer, is recommended. The range of lighting standards and lighting products on the market today is very broad…. If action on lighting in the countryside is to be effective it will require the close co-operation and participation of all those involved in planning, designing, and installing lighting schemes. The responsibility for tackling lighting issues is very much a shared one …. Local authority planners should recognize the cumulative impacts of lighting on countryside character, and be more pro-active. They should consider the need for policies on lighting in the development plan …. Developers should look differently upon lighting than they did in the past, and should not automatically assume that it is a good thing. This implies a more critical assessment of lighting need and alternatives, and a greater willingness to consider the removal or upgrading of intrusive lighting. In judging the costs of lighting they should take a long term view and give due weight to energy and maintenance costs as well as capital costs …. Lighting

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

> engineers and designers should adopt a more structured approach to assessing the environmental impacts of lighting installations …. Manufacturers and suppliers of lighting equipment should provide a design service that is as impartial and responsible as possible, and should focus increasingly on high quality lighting products …. In relation to security lighting that is intended for DIY installation, retailers have a special responsibility to ensure that good information is available on how to choose appropriate equipment, minimize light levels, and control light pollution through good installation …. Lastly, members of the public have a vital rôle in the control of light pollution. They are responsible not only for most domestic security lighting, but also for much of the small scale lighting on commercial and business premises that does not need planning permission. They should take great care in the selection and installation of lighting equipment, and if in doubt, should always seek professional advice.
>
> (Crown copyright is reproduced with the permission of the Controller of Her Majesty's Stationery Office).

In 1998, the Environment Agency of Japan, in collaboration with the CIE Japanese section, published its *Guidelines for Light Pollution: Aiming for Good Lighting Environments*. In his introduction to this minutely detailed 93-page document, Syuzo Isobe, of the National Astronomical Observatory at Mitaka, Tokyo, describes the necessity for the intervention of lighting engineers on a larger scale, good monitoring and the increased use of satellite technology in the measurement of wasted energy. The document recommends close inspection of proposed lighting by the use of standardized checking procedures for all lighting tasks, and lists procedures to be undertaken. In the body of the text, we read:

> Checklist for outdoor lighting:
>
> Targets: facility maintenance companies, facility managers, designers of environmental lighting, and citizens.
>
> When installing lighting that takes into consideration the lighting environment … Studies for sufficient and efficient lighting are necessary. For these studies, it is important to clearly identify the objectives for each individual lighting installation, and this is related to the suppression of spill light or obtrusive light, and attaining a more efficient lighting facility.
>
> Check procedure:
>
> Preparation of an 'overall lighting plan':
>
> (1) Understanding the type of facility (e.g. residential, business, public);
> (2) Selection of lighting group (type of function, e.g. transit, crime prevention, decorative);
> (3) Understanding the surrounding environment;
> (4) Arrangement of compatibility of lighting groups;
> (5) Preparation of 'overall check sheet' and 'lighting group arrangement plan'.
>
> (Reproduced by kind permission of Syuzo Isobe)

Appendix 10

The IDA's

"Simple Guidelines for Lighting Regulations for Small Communities, Urban Neighborhoods, and Subdivisions"

The Purpose of the Regulation Is To

- Permit reasonable uses of outdoor lighting for night-time safety, utility, security, and enjoyment while preserving the ambiance of the night;
- Curtail and reverse any degradation of the night-time visual environment and the night sky;
- Minimize glare and obtrusive light by limiting outdoor lighting that is misdirected, excessive, or unnecessary;
- Conserve energy and resources to the greatest extent possible;
- Help protect the natural environment from the damaging effects of night lighting.

All outdoor lighting fixtures (luminaires) shall be installed in conformance with this Regulation and with the provisions of the Building Code, the Electrical Code, and the Sign Code, as applicable and under permit and inspection, if such is required.

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

Comment: Practical Considerations

1. The idea that more light always results in better safety and security is a myth. One needs only the right amount of light, in the right place, at the right time. More light often means wasted light and energy.
2. Use the lowest wattage of lamp that is feasible. The maximum wattage for most commercial applications should be 250 W of high intensity discharge lighting should be considered the maximum, but less is usually sufficient.
3. Whenever possible, turn off the lights or use motion sensor controlled lighting.
4. Incorporate curfews (i.e. turn lights off automatically after a certain hour when businesses close or traffic is minimal). This is an easy and fast way to initiate dark sky practices.

Maximum Lamp Wattage and Required Luminaire or Lamp Shielding

All lighting installations shall be designed and installed to be fully shielded (full cut-off), except as in exceptions below, and shall have a maximum lamp wattage of 250 W HID (or lumen equivalent) for commercial lighting, 100 W incandescent, and 26 W compact fluorescent for residential lighting (or approximately 1,600 lumens). In residential areas, light should be shielded such that the lamp itself or the lamp image is not directly visible outside the property perimeter.

Lighting That Is Exempt from These Regulations

1. Lighting in swimming pools and other water features governed by Article 680 of the National Electrical Code.
2. Exit signs and other illumination required by building codes.
3. Lighting for stairs and ramps, as required by the building code.
4. Signs are regulated by the sign code, but all sign lighting is recommended to be fully shielded.
5. Holiday and temporary lighting (less than 30 days use in any 1 year).
6. Football, baseball, and softball field lighting; only with permit from the authority recognizing that steps have been taken to minimize glare and light trespass, and utilize sensible curfews.
7. Low voltage landscape lighting, but such lighting should be shielded in such a way as to eliminate glare and light trespass.

Additional Requirements

- Lighting attached to single-family home structures should not exceed the height of the eave.
- Residential pole height restrictions can be considered to control light trespass on adjacent properties.

Notes

1. The general belief that more light means better safety and security is just a myth. All that is needed is the right amount, in the right place, at the right time. More light just means wasted light and energy.
2. Use the lowest wattage of lamp as possible. For cost saving purposes, consider compact fluorescent lamps rather than incandescent, as they use much less energy and have a much longer lifetime.
3. Whenever possible, turn off the lights.

Appendix 11

Extracts from the Revised Tucson and Pima County Outdoor Lighting Control Ordinances

The complete document is available as Information Sheet 91 on the IDA website (see Bibliography). Reproduced with permission.

Ordinance No. 8210.
Tucson/Pima County Outdoor Lighting Code, 21 March 1994.

Section 1

Purpose and Intent. The purpose of this Code is to provide standards for outdoor lighting so that its use does not unreasonably interfere with astronomical observations. It is the intent of this Code to encourage, through the regulation of the types, kinds, construction, installation, and uses of outdoor electrically powered illuminating devices, lighting practices and systems … (conservation of) energy without decreasing safety, utility, security, and productivity while enhancing nighttime enjoyment of property within the jurisdiction.

Section 2

…All outdoor electrically powered illuminating devices shall be installed in conformance with the provisions of this Code, the Building Code, the Electrical Code, and the Sign Code of the jurisdiction as applicable and under appropriate permit and inspection.

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

Section 4 Definitions

…Section 4.3. "Outdoor light fixture" means outdoor electrically powered illuminating devices, outdoor lighting or reflective surfaces, lamps and similar devices, permanently installed or portable, used for illumination or advertisement. Such devices shall include, but are not limited to search, spot, and flood lights for:

(1) buildings and structures; (2) recreational areas; (3) parking lot lighting; (4) landscape lighting; (5) billboards and other signs (advertising or other); (6) street lighting; (7) product display area lighting; (8) building overhangs and open canopies.

Section 5 Shielding

All nonexempt outdoor lighting fixtures shall have shielding as required by Table 2 of this Code.

…Section 5.1. "Fully shielded" means outdoor light fixtures shielded or constructed so that no light rays are emitted by the installed fixture at angles above the horizontal plane as certified by a photometric test report.

…Section 5.2. "Partially shielded" means outdoor light fixtures shielded or constructed so that no more than 10% of the light rays are emitted by the installed fixture at angles above the horizontal plane as certified by a photometric test report.

Section 9 Prohibitions

…Section 9.1. Mercury Vapor Lamps Fixtures and Lamps. The installation, sale, offer for sale, lease or purchase of any mercury vapor fixture or lamp for use as outdoor lighting is prohibited.

…Section 9.2. Certain Other Fixtures and Lamps. The installation, sale, offering for sale, lease or purchase of any low pressure sodium, high pressure sodium, metal halide, fluorescent, quartz or incandescent outdoor lighting fixture or lamp the use of which is not allowed by Table is prohibited.

…Section 9.3. Laser Source Light. Except as provided in minor Section 9.4, the use of laser source light or any similar high intensity light for outdoor advertising or entertainment, when projected above the horizontal is prohibited.

Section 9.4. Searchlights. The operation of searchlights for advertising purposes is prohibited in Area A and is prohibited in unincorporated Pima County. In the territorial limits of the City of Tucson, the operation of searchlights for advertising purposes is prohibited in Area A and is prohibited in Area B between 10:00 p.m. and sunrise the following morning.

Table 2 Shielding requirements (area A: 35 miles around Kitt Peak National Observatory, 25 miles around Mount Hopkins Observatory; area B: all area outside area A outside limits of Indian reservations – BM)

	Area A	Area B
Fixture lamp type	Shielded	Shielded
Low pressure sodium[a]	Partially	Partially
High pressure sodium	Prohibited except fully shielded on arterial streets and collector streets of 100 ft or more in right of way width.	Fully
Metal halide	Prohibited[b]	Fully[c, d]
Fluorescent	Fully[e, f]	Fully[e, f]
Quartz[g]	Prohibited	Fully
Incandescent greater than 160 W	Fully	Fully
Incandescent 160 W or less	None	None
Any light source of 50 W or less	None	None
Glass tubes filled with neon, argon, krypton	None	None
Other sources	As approved by the Building Official	

[a] This is the preferred light source to minimize undesirable light emission into the night sky affecting astronomical observations. Fully shielded fixtures are preferred but not required.
[b] Fully shielded and installed metal halide fixtures shall be allowed for applications where the designing engineer deems that color rendering is critical.
[c] Metal halide lighting, used primarily for display purposes, shall not be used for security lighting after 11:00 pm or after closing hours if before 11:00 pm. Metal halide lamps shall be installed only in enclosed luminaires.
[d] For filtering requirements for metal halide fixture lamp types see Section 6.
[e] Outdoor advertising signs of the type constructed of translucent materials and wholly illuminated from within do not require shielding. Dark backgrounds with light lettering or symbols are preferred, to minimize detrimental effects. Unless conforming to the above dark background preference, total lamp wattage per property shall be less than 41 W in Area A.
[f] Warm white and natural lamps are preferred to minimize detrimental effects.
[g] For the purposes of this Code, quartz lamps shall not be considered an incandescent light source.

Section 10 Special Uses

Section 10.1. Recreational Facilities. Any light source permitted by this Code may be used for lighting of outdoor recreational facilities (public or private), such as, but not limited to, football fields, soccer fields, baseball fields, softball fields, tennis courts, auto race tracks, horse race tracks or show areas, provided all of the following conditions are met:

(a) Lighting for parking lots and other areas surrounding the playing field, court, or track shall comply with this Code for lighting in the specific Area as defined in Sections 4.4 and 4.5 of this Code.

(b) All fixtures used for event lighting shall be fully shielded as defined in Section 5 of this Code, or be designed or provided with sharp cut-off capability, so as to minimize up-light, spill-light, and glare.
(c) All events shall be scheduled so as to complete all activity before or as near to 10:30 p.m. as practical, but under no circumstances shall any illumination of the playing field, court, or track be permitted after 11:00 p.m. except to conclude a scheduled event that was in progress before 11:00 p.m. and circumstances prevented concluding before 11:00 p.m.

Exception: (City only.) Any portion of a recreational facility located within 300 ft of a road or street designated as a scenic route shall be lighted using only fixtures approved for use under this Code for the Area, as defined in Sections 4.4 and 4.5 of this Code, in which said recreational facility is located.

Exception: (County only.) Recreational facilities located along roads and streets designated as scenic routes shall be lighted using only fixtures approved for the Area in which they are located.

Section 10.2. Outdoor Display Lots. Any light source permitted by this Code may be used for lighting of outdoor display lots such as, but not limited to, automobile sales or rental, recreational vehicle sales, or building material sales, provided all of the following conditions are met:

(a) Lighting for parking lots and other areas surrounding the display lot shall comply with this Code for lighting in the specific area as defined in Sections 4.4 and 4.5 of this Code.
(b) All fixtures used for display lighting shall be fully shielded as defined in Section 5 of this Code, or be designed or provided with sharp cut-off capability, so as to minimize up-light, spill-light, or glare.
(c) Display lot lighting shall be turned off within 30 min after closing of the business. Under no circumstances shall the full illumination of the lot be permitted after 11:00 p.m. Any lighting used after 11:00 p.m. shall be used as security lighting.

Section 12 Other Exemptions

…Section 12.1. Nonconformance

1. Mercury vapor lamps in use for outdoor lighting on the effective date of the ordinance codified in this chapter shall not be so used.
2. (City) Bottom-mounted outdoor advertising sign lighting shall not be used. (County) Bottom-mounted outdoor advertising sign lighting shall not be used, except as provided in Section 7.
3. All other outdoor light fixtures lawfully installed prior to and operable on the effective date of the ordinance codified in this chapter are exempt from all requirements of this Code except those regulated in Section 7 and in minor

Sections 9.3 and 9.4 and in Section 10. There shall be no change in use or lamp type, or any replacement or structural alteration made, without conforming to all applicable requirements of this Code.

…Section 12.2. Fossil Fuel Light. All outdoor light fixtures producing light directly by the combustion of natural gas or other fossil fuels are exempt from all requirements of this Code.

…Section 12.3. State and Federal Facilities. Outdoor light fixtures installed on, and in connection with those facilities and land owned or operated by the federal government or the state of Arizona, or any department, division, agency or instrumentality thereof, are exempt from all requirements of this Code. Voluntary compliance with the intent of this Code at those facilities is encouraged.

Section 15 Violation

It shall be a civil infraction for any person to violate any of the provisions of this Code. Each and every day during which the violation continues shall constitute a separate offense.

Section 16 Enforcement and Penalty

…Section 16.1. (City only) Pursuant to Section 28–12 of the Tucson Code:

1. When a violation of this Code is determined, the following penalty shall be imposed:
   (a) A fine of not less than 50 dollars nor more than 1,000 dollars per violation. The imposition of a fine under this Code shall not be suspended.
   (b) Any other order deemed necessary in the discretion of the hearing officer, including correction or abatement of the violation.
2. Failure of a defendant to comply with any order contained in a judgment under this Code shall result in an additional fine of not less than 50 dollars nor more than 1,000 dollars for each day the defendant fails to comply.

Section 16.1. (County only) A violation of this Code is considered a civil infraction. Civil infractions shall be enforced through the hearing officer procedure provided by A.R.S. Section 11–808 and Sections 18.95.030, 18.95.040, and 18.101.60 of this Code (The numbering scheme of the Sections is different in the County Code). A fine shall be imposed of not less than 50 dollars nor more than 700 dollars for any individual or 10,000 dollars for any corporation, association, or other legal entity for each offense. The imposition of a fine under this Code shall not be suspended.

Glossary

Ambient light The total light level or effect, or amount of light perceived, in one's surroundings.

Baffle A plate inserted within or just outside a luminaire to shield the light from direct view.

Ballast Electrical devices used in conjunction with a discharge lamp to start and control it.

Candela (cd) or standard candle The SI unit of luminous intensity.

CfDS The British Astronomical Association's Campaign for Dark Skies. See Appendix A.3 and Bibliography.

CFL Compact fluorescent lamp.

CIE The *Commission Internationale de l'Eclairage* (International Lighting Commission), based in Vienna. See Bibliography.

Color rendering/rendition The perceived effect on objects of different colours of lights of different types.

Color temperature This term describes the actual colour of the light source itself, as opposed to that of the light issuing from it.

Column The post upon which a lamp is mounted.

Cones See **rods and cones**.

Dark adaptation The transition of visual processes within the eye to darker surroundings. See **Rods and cones**.

Disability glare (veiling luminance) Glare causing reduced visual performance. See Sect. 1.2.

Discomfort glare Glare producing discomfort or annoyance without necessarily interfering with visual performance. See Sect. 1.2.

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

FCO This stands for full cut-off, referring to a lamp with a flat glass panel beneath which, when mounted horizontally, emits no light above the horizontal. See also **SCO**.

Fluorescent A long-life, relatively cheap whitish light source based on a gas discharge process, where electrons pass through a tube and interact with a phosphor coating.

Flux Luminous flux is the rate of flow of particles of light energy, measured in watts or ergs/s.

Fovea A small central depression in the back of the retina containing cone cells: the area of sharpest vision.

Full cut-off See **FCO**.

IDA The International Dark-Sky Association. See Appendix A.2 and Bibliography.

IESNA/IES The Illuminating Engineering Society of North America. The USA's professional guidance body for lighting engineers. See Bibliography.

ILP The Institution of Lighting Professionals. The UK's professional guidance body for lighting engineers. See Bibliography.

Incandescent Describes a light source based on electricity passing through a thin filament (usually tungsten) which glows brightly.

Intrusive light See **light trespass**

KWh Kilowatt-hour: unit of energy equal to the work done by 1,000 W of power acting for 1 h.

LED Light-emitting diode.

Light spill The emission of light outside the premises which the lighting is supposed to illuminate.

Light trespass (intrusive light) Troublesome light entering areas or premises outside the boundary of the premises to be illuminated. UK campaigners against light waste tend not to use the term *trespass*, which has a specific meaning in law. It is not normally the intention of the owners of intrusive lights to cause a problem. They simply do not realise that they are.

Lumen (lm) The SI unit of luminous flux, being the flux emitted in a solid angle of 1 steradian by a point source with uniform intensity of 1 candela (q.v.).

Luminaire A word not found in many dictionaries, but widely used in the lighting community to denote the lamp and its surrounding casing and optics.

Lux (lx) The SI unit of illumination, being a luminous flux of 1 lumen (q.v.) per square metre. The value for the full Moon is about 0.2–0.3 lux.

Melatonin A hormone (N-acetyl-5-methoxytryptamine) secreted during the hours of darkness by the pineal gland.

Obtrusive light Light emitted where it is not needed, causing nuisance or environmental degradation.

Photometry The measurement of the level and distribution of light.

Reflectance The amount of light reflected by a given surface (the ratio of the reflected flux to the incident flux).

Reflectivity The ability of a surface to reflect radiation (technically, equal to the reflectance of a layer of material sufficiently thick for the reflectance not to depend on the thickness).

Rods and cones Cells in the retina of the eye. Rods are cylindrical cells containing rhodopsin ('visual purple'), and are sensitive to dim light but not to colour. Cones are conical cells which are sensitive to color and bright light. The process of dark adaptation involves the rods taking over visual duties from the cones. Interestingly, there are no rods in the centre of the fovea (*q.v.*), which explains the astronomer's 'averted vision' trick (objects appearing more distinct if you look slightly to one side of them).

SCO Semi-cut-off: a lamp type which has a shallow bowl beneath, and emits little or no light skywards.

SON Another name for high-pressure sodium sources (see Sect. 1.3).

SOX Another name for low-pressure sodium sources (see Sect. 1.3).

Skybeam, sky beam A concentrated beam of light sent into the sky deliberately, usually for the purposes of advertising (often erroneously called a 'laser').

Sky glow, skyglow Unwanted light emitted into the night sky from poorly aimed lamps.

Stray light See **Light spill**.

Street furniture All manufactured items commonly seen along roadsides. e.g. lighting columns, telephone poles.

Veiling luminance See **Disability glare**.

Visibility Clarity of vision; how well we see something. The purpose of a good light should be to increase visibility: to reveal and not conceal.

UWLR, ULR, Upward flux The abbreviations stand for Upward (Waste) Light Ratio. All these terms refer to the relative amount of the light emitted above the horizontal.

Bibliography

British Astronomical Association (BAA)/Council for the Protection of Rural England (CPRE)
Starry starry night (April 2000, revised 2010)

BAA Campaign for Dark Skies (CfDS)
Blinded by the light? A handbook on light pollution (2009)
Domestic and commercial security lighting (2009)
CfDS Newsletter (twice yearly)

The CfDS Website Has a Light Pollution Reading List
www.britastro.org/dark-skies/readlist.htm#tech
All BAA/CfDS publications are available from BAA, Burlington House, Piccadilly, London W1J 0DU, UK. (0)207 734 4145.
E-mail: office@britastro.org

British Standards Institution (BSI)
British Standard (BS)5489 (Code of practice for road lighting). Available from the BSI, 389 Chiswick High Rd, London W4 4AL, UK. (0)208 996 9001

Chartered Institution of Building Services Engineers/Institute of Light and Lighting
Lighting guides (LG1 Industrial, LG4 Sports, LG6 The Exterior Environment). Available from CIBSE/ILL, 222 Balham High Rd, London SW12 9BS, UK. (0)208 675 5211

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

Commission Internationale de l'Eclairage (CIE)
Guidelines for minimizing urban sky glow near astronomical observatories
Guide for floodlighting
Recommendations for the lighting of roads for motor and pedestrian traffic
Guidelines for minimizing sky glow
Guide to the lighting of urban areas. Available from CIE, Central Bureau, Kegelgasse 27, Vienna, Austria. (001)431 714 3187

Countryside Commission/Department of the Environment (UK)
Lighting in the countryside – towards good practice (ISBN 0-11-753391-2). Available from The Stationery Office, PO Box 276, London SW8 5DT, UK. (0)207 873 9090

Department of Transport (UK)
Road lighting and the environment. Available from DoT Sales Unit, Government Building, Block 3, Spur 2, Lime Grove, Eastcote HA4 8SE, UK. (0)208 429 5170

International Dark-Sky Association
IDA newsletter (quarterly). Available from ida@darksky.org

The IDA website has a great choice of articles, extracts and references
www.darksky.org

Illuminating Engineering Society of North America
Recommended practice on roadway lighting (IESNA RP-8-00). Available from IESNA, 120 Wall Street, New York, NY 10005, USA. 212-248-5000. www.iesna.org

Institution of Lighting Professionals (ILP)
Guidance notes for the reduction of light pollution
Lighting the environment – a guide to good urban lighting
Domestic security lighting, friend or foe? Available from the ILP, Lennox House, 9 Lawford Rd, Rugby CV21 2DZ, UK. (0)1788 576492. www.theilp.org

Royal Commission on Environmental Pollution
Artificial light in the environment (2009) www.official-documents.gov.uk/document/other/…/9780108508547.pdf

Royal Fine Art Commission
Lighten our darkness. Available from RFAC, 7 St James's Square, London SW1Y 4JU, UK. (0)207 839 6537

Recommended Reading and Websites

Avery D (1999) The proper use of light therapy. Dir Psychiatr 19:379–398
Baddiley Dr CJ (2007) Towards understanding skyglow. Available through CfDS and ILP
Bower J (2000) The dark side of light. Audubon Mag 102(2):92–97
Bruce-White C, Shardlow M (2011) Review of the impact of artificial light on invertebrates. Buglife, Peterborough, www.buglife.org.uk/News/newsarchive/News+Archive+2011/Save+bugs+from+light+pollution
Campaign for Dark Skies (2009) Blinded by the light? A handbook on light pollution. Order via www.britastro.org/dark-skies
Cinzano P, Falchi F, Elvidge D (2001) The first world atlas of artificial night sky brightness. Mon Not R Astron Soc 328(3):689–707
Clark BAJ (2000) Outdoor lighting principles for Australia in the 21st century. www.gsat.edu.au/astrovic
Coren S (1996) Sleep thieves: an eye-opening exploration into the science and mysteries of sleep. Free Press, New York. ISBN 0-684-82304-7, in IDA (www.darksky.org) information sheet 108
CPRE (2003) Night blight. www.cpre.org.uk
Crow D (1999) The story of light. Light J, Jan–Feb
DEFRA (2000) Our countryside: the future – a fair deal for rural England, The UK Stationery Office. www.defra.gov.uk/rural/ruralwp/whitepaper/chapter9.htm#9.4.2
Eisenbeis G (2006) Artificial night lighting and insects: attraction of insects to streetlamps in a rural setting in Germany, chapter 12. In: Rich C, Longcore T (eds) Ecological consequences of artificial night lighting. Island Press, Washington, DC
FLAP: Fatal Light Awareness Program, Toronto. Various publications. www.flap.org
Haim A, Kloog I, Portnov BA, Rennert HS (2011) Does the modern urbanized sleeping habitat pose a breast cancer risk? Chronobiol Int 28(1):76–80
Harris J (1993) Lighting the queen's highway. Light J 58(4):245
Henshaw C (1994) The environmental effects of light pollution. J Br Astron Assoc Lett 104(1):3. Available in pdf format at http://articles.adsabs.harvard.edu/full/seri/JBAA./0104/0000313.000.html
Henshaw C, Cliff G (2006) Is light pollution killing our birds? Challenge Mag, Summer
Huemer P, Kühtreiber H, Tarmann G (2010) Anlockwirkung moderner Leuchtmittel auf nachtaktive Insekten. www.hellenot.org
Isobe S, Environment Agency of Japan (1998) Guidelines for light pollution: aiming for good lighting environments
Jewkes P (1998) Light pollution: a review of the law. J Plan Environ Law
Jewkes P (1998b) Light pollution and the law: what can you do? J Br Astron Assoc 108(5):258–260
Lockley S (2009) Human health implications of light pollution. In: Mizon W (ed) Blinded by the light? CfDS 2009. British Astronomical Association, London, pp 21–25
Klinkenborg V (2008) Our vanishing night. National Geographic
McNally D (ed) (1994) The vanishing universe: adverse environmental impacts on astronomy. Cambridge University Press, Cambridge. ISBN 0-521-45020-9
Kloog I, Haim A, Stevens RG, Barchana M, Portnov BA (2008) Light at night co-distributes with incident breast but not lung cancer in the female population of Israel. Chronobiol Int 25(1):65–81
Marchant P (2006) Shining a light on evidence-based policy: street lighting and crime. Crim Just Matter no. 62. The Centre for Criminal Justice Studies, Kings College, London, p 18
Marchant PR (2011) Have new street lighting schemes reduced crime in London? Radic Stat 104:39–48

Mizon B (1998) Heaven's light. Astron Now. Light pollution Mizar Astronomy/CfDS, 2000 with Baskill D (2010) Stolen stars: a young adult's guide to light pollution. www.britastro.org/dark-skies
de Molenaar JG et al (2003) Road illumination and nature. IV. Effects of road lights on the spatial behaviour of mammals. Alterra Green World Research, Wageningen
Morgan-Taylor M (1997) And God divided the light from the darkness: has humanity mixed them up again? Environ Law Manage 9(1):32–39
Mostert H (1983) A clear-sky detector using reflected artificial light. J Br Astron Assoc 93(5):205–209
Nash D. Filters. www.xmission.com/~dnash
Pearce F (1995) Declaring a curfew on aurora metropolis. New Sci 145:44–45
Pollard N (1994) Skyglow-conscious lighting design. Int J Light Res Technol 26(3):151–156
Floodlighting the outdoor environment – a waste of energy? http://www.iaeel.org/iaeel/Archive/Right_light_proceedings/Proceedings_body/BOK3/200/3099.PDF
Purves L (1998) Light pollution. In: Barnett A, Scruton R (eds) Town and country. Cape, London. ISBN 0-22-405-2500
Ramsey M, Newton R (1991) The influence of street lighting on crime and fear of crime. Home Office Crime Prevention Unit (HOCPU) papers 28 and 29. Home Office, London
Ratledge D (ed) (1997) The art and science of CCD Astronomy. Springer, London
Rich C, Longcore T (2006) Ecological consequences of artificial night lighting. Island Press, Washington, DC. ISBN 1-55963-128-7
Sherman L, Gottfredson D, MacKenzie D, Eck J, Reuter P, Bushway S (1997) Preventing crime: what works, what doesn't, what's promising. A report to the United States Congress. Prepared for the National Institute of Justice. Department of Criminology and Criminal Justice, University of Maryland at College Park
Simpson M (1995) Social factors behind the development of outdoor lighting. Light J 60(3):137
Tonkin S (2000) Astro FAQs. Springer, ISBN 1-85233-272-7. Website (filters, etc.). www.astunit.com
Witherington BE (1997) The problem of photopollution for sea turtles and other nocturnal animals. In: Clemmens JR, Buckholz R (eds) Behavioural approaches to conservation in the wild. Cambridge University Press, Cambridge, pp 303–328
Wright P, Paterson J. Understanding and dealing with obtrusive light – a practical guide to help planners and designers to appreciate and deal with problems of light pollution. www.lcads.com/pollution/ObtrusiveMain.html

A Long List of Articles on Light Pollution Can Be Found on

http://www.weasner.com/etx/lp/index.html

Websites on Light Pollution

calgary.rasc.ca/lp/frame.html
www.environmental-protection.org.uk/neighbourhood-nuisance/light-pollution
www.globeatnight.org
www.jshine.net/astronomy/dark_sky
www.lightpollution.it
www.lightpollution.org.uk

www.need-less.org.uk
www.njaa.org/light.html
www.utahskies.org/light-pollution

Star Atlases and Observing Guides

Burnham R (1978) Burnham's celestial handbook, 3 vols. Dover, New York. ISBN 0-486-24063-0
Kanipe J (1999) A skywatcher's year. Cambridge University Press, New York. ISBN 0-521-63405-9
Karkoschka E (1999) The observer's sky atlas. Springer, New York. ISBN 0-387-98606-5
Ridpath I (ed) (1989) Norton's 2000.0 star atlas and reference handbook. Longman/Wiley, ISBN 0-470-21460-0: USA; 0-582-03163-X: UK
Tirion W, Rappaport B, Lovi G (1987) Uranometria 2000.0, 2 vols. Willmann-Bell, Richmond. ISBN 0-943396-14-X

About the Author

Bob Mizon, MBE, FRAS, is a planetarium operator and astronomy lecturer, best known in the scientific and environmental community as the co-coordinator of the British Astronomical Association's Campaign for Dark Skies, which aims to turn back the tide of light pollution which has seriously affected our view of the stars over the last 60 years.

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

Object Index

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,

Subject Index

B. Mizon, *Light Pollution: Responses and Remedies*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-3822-9,