

# STARLIGHT RESERVE



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# STARLIGHT RESERVE

CONCEPT – DIMENSIONS - CATEGORIES – CRITERIA - RECOMMENDATIONS

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# Starlight Reserve Concept

## 1.

### BACKGROUND

The Declaration in Defence of the Night Sky and the Right to Starlight was approved in the occasion of the Starlight Conference, held on the island of La Palma in April 2007. It constitutes the general and conceptual framework of the Starlight initiative. The proposal to develop a "Starlight Reserve" concept was one of the additional recommendations to the Starlight Declaration, to be carried out with the support of the Organizations which promoted the Declaration and the Starlight Scientific Committee, in cooperation with the World Heritage Centre through its thematic initiative "Astronomy and World Heritage

Between 10 and 19 October (2007), the participants in the Working Meeting "Starlight Reserve" Concept, held at the UNESCO HQ, Paris, World Heritage Centre, agreed the development of its contents and action plan, as it is stated in the following introduction:

*Recognizing* the importance to promote the Declaration in Defence of the Night Sky and the Right to Starlight (adopted in La Palma, April 2007) through the different UNESCO Programmes and Initiatives within the framework of the UNESCO Conventions,

*Considering* that the light pollution as one of the causes of the gas emissions must be considered as an imminent threat for the environment, as well as that climate change poses a threat to the outstanding universal values of World Heritage sites,

*Recognizing* that the preservation of dark skies is an important and necessary part in the process of the protection and safeguarding of natural and cultural properties worldwide,

*Following* the call of the UNESCO Director-General for "an integrated approach to issues of environmental preservation and sustainable development" (the UNESCO publication "Case Studies on Climate Change and World Heritage"),

The participants of the joint working group on "Starlight Reserve" Concept and the Initiative "Astronomy and World Heritage" recommended adopting the following plan of actions aiming:

- to elaborate the Concept of “Starlight Reserve”;
- to identify the different categories of areas, reserves and properties accordingly to this Concept;
- to establish general technical recommendations in regard to the starlight protection, related to the safeguarding of natural and cultural properties, lighting pollution and intelligent lighting;
- to integrate these recommendations to the different World Heritage Programmes and Initiatives;
- to evaluate the possibilities of the nomination of the “Starlight Reserve” on the World Heritage List and/or as the Biosphere Reserve.

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A Starlight Reserve is a site where a commitment to defend the night sky quality and the access to starlight has been established. Its main function will be to preserve the quality of the night sky and its associated values, being them cultural, scientific, astronomical, natural, or landscape-related.

A Starlight Reserve will have a core or dark zone. This is an unpolluted area where natural night sky light conditions are kept intact. This core zone will be protected by a buffer or protection zone to avoid that the adverse effects of air and light pollution would reach the core zone. Finally, an external zone where criteria of intelligent and responsible lighting will be enforced, protecting night sky quality from other harmful factors such as air pollution.

Each Starlight Reserve requirements would be specific to the characteristics, singularities and functions the site, being them related to the preservation of the astronomical observation quality, with nocturnal wildlife conservation, maintenance of the integrity of nighttime landscapes or cultural heritage scenarios related to astronomy.

The Starlight Reserve concept can be applied to other types of protected areas, including those regarding natural and cultural heritage. A Starlight Reserve declaration will be accompanied by a participative action plan and an ensemble of recommendations aimed to preserve and recover the night sky quality up to the feasible limits, paying attention to the related cultural, educational, scientific and environmental benefits.

The objectives and functions of Starlight Reserves are guided by the principles contained in the Declaration in Defence of the Night Sky and the Right to Starlight.



### The cultural dimension

"The sky has always been and still is an inspiration for mankind. However, its contemplation has become increasingly difficult and, even, for the young generations is beginning to be unknown. An essential element of our Civilization and culture is getting lost quickly, and this loss will affect all the Countries in the world"<sup>1</sup>.

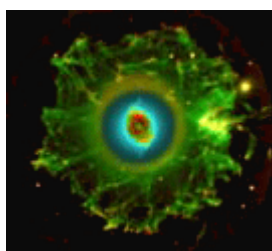
Interest in astronomy, or simple contemplation of starry skies, has always had profound implications for philosophy, science, arts, culture and for the general conception of the universe in every community all over the world. Putting into value, protecting and promoting the tangible and intangible cultural heritage associated to night sky vision, usually poorly known and little valued, and often in danger, would be an essential function of Starlight Reserves.

Following the example of UNESCO's thematic initiative "Astronomy and World Heritage", the establishment of links between science and culture, on the basis of research aimed at acknowledging the cultural and scientific values of heritage sites connected with astronomy, should be promoted.

A large part of our generation is the first in history that grew up without a direct contact with the beauty of a starry sky, in an environment where these cultural references are falling into the oblivion. Therefore, we need improving education systems, as well as dissemination and access to available information on the cultural dimension and value of the night sky. Even though astronomy is normally included in educational programmes, it is not often linked with each site's related cultural heritage.

The night sky should keep being one of the big windows open to the inspiration and cultural enrichment of human communities, with new generations becoming their best guardians.

*"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"* (Declaration in Defence of the Night Sky and the Right to Starlight).



### Preservation of the astronomical sky quality

"The sky, our common and universal heritage, is an integral part of the environment perceived by humanity. Humankind has always observed the sky either to interpret it or to understand the physical laws that govern the universe"<sup>2</sup>.

Astronomy has had an undeniable influence within science development and has contributed to many technological advances which defined human progress throughout the history.

<sup>1</sup> Declaration of the IAU/ICSU/UNESCO-1992.

<sup>2</sup> Explanatory Note concerning the Proclamation of 2009 as International Year of Astronomy (33rd session of the UNESCO General Conference).

Nevertheless, the continual stream of benefits brought by this branch of science is often not known by most people.

Ground-based observatories are exceptional windows for the observation of the universe, and they have provided the vast majority of our knowledge of astronomy. However, present technical requirements restrict suitable areas to very specific and limited locations offering good conditions for the development of advanced astronomy, and of optical and infrared astronomy in particular.

The Earth's atmosphere is a major limiting factor for astronomy at optical wavelengths. Although astronomy from space does not suffer from this blurring, space astronomy is extremely expensive. The very best astronomical sites are places located at high altitudes, with little turbulence, such as in the west coasts of continents, or on some oceanic islands. They must also be located at latitudes with good weather <sup>3</sup>, with less air pollution and low aerosol content. Excepting in a few exceptional cases, high mountain areas isolated from the temperature of the ocean and coastal mountains near to cold oceans with stable, subtropical anticyclone conditions are the best possibilities. These are a limited resource that needs to be protected.

However, the sky quality in many of these privileged zones can be perturbed by external factors of different kinds. Optical astronomy needs dark skies. Therefore light pollution is one of the main threats because it reduce the natural sky brightness. Atmospheric pollution is a further impact to the astronomical quality of the sky.

Radio astronomy made decisive contributions to several fundamental discoveries in the last century. Nowadays this branch of astronomy is also threatened due to radio interference, generated by several causes such as mobile phones or radio/TV frequency signals, which invade the radioelectric spectrum in which astrophysical observations are made.

Next to these best astronomical sites there is a large number of locations equally worth identifying and preserving, which are acceptably good for certain specific astronomical observations or for the development of educational and informative activity.

The defence of astronomical sky quality, as well as the establishment of measures, zonation criteria, and regulations to avoid its possible deterioration, is the basic function of the application of the Starlight Reserve concept to the best sites for astronomical observation. People involvement through education and information on astronomy and its associated benefits is a priority factor to achieve sky conservation for astronomy and science.

*"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."* (Declaration in Defence of the Night Sky and the Right to Starlight).

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<sup>3</sup> Best sites for optical astronomy with these characteristics are found in: the Canary Islands (La Palma-Tenerife), the coastal mountains of Chile, the Hawaiian Islands (Mauna Kea, Haleakala), Baja California and coastal mountains of southern California Namibia, where there is a high plateau. Singular locations are also found in Uzbekistan, North Africa or Argentina, and also some interesting areas in Antarctica.



## Clear Skies and Biodiversity

The loss of quality of nocturnal skies, caused by the negative effects of atmospheric emissions and of the increased intrusion of badly designed artificial lights, has become a serious threat for several species, disturbing their habits and habitats, as well as the basic functions of ecosystems.

Darkness and natural night light are indispensable for the healthy functioning of organisms and ecosystems. We usually forget that life lives 24 hours a day and that ecosystems adapted themselves to the natural rhythms of moon and stars during millions of years of evolution. As over half of the creatures living on this planet are nocturnal, any degradation in the quality of sky, by day or by night, will have a profound effect on their behaviour and on the equilibrium of the biosphere.

Light pollution in particular, turned out to be a factor having a widespread, negative impact on many different species. Scientific evidence for this impact in migratory birds, hatchling sea turtles, and insects is striking, because of the large-scale mortality that has occurred as a result of artificial night lighting.

Light pollution can confound animal navigation (many species use the horizon and stars for orientation), alter competitive interactions, mutualisms and reproduction behaviour, change the natural predator-prey relationship and even affect animal physiology. Amphibians are well-studied in this sense, as well as a number of nocturnal or crepuscular mammals such as bats, some primates, many rodents and marsupials, which all suffer from what is now called "biological photopollution". Worrying data on light pollution effects on flora and phytoplankton are also being obtained.

Applying the Starlight Reserve concept, especially in the case of natural areas, would allow setting new bases for the safeguard of Earth's biological diversity. The night sky quality dimension should be at least included in the management and conservation of protected areas and important habitats. Ramsar wetlands, natural areas declared World Heritage Sites, Biosphere Reserves, National Parks, marine sanctuaries, and other protected areas have to face up to a new responsibility: saving life at night

"The negative effects of emissions and of the increased intrusion of artificial light on the atmospheric quality of nocturnal 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".

"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 to include the protection of clear night skies as a key factor strengthening their mission in conserving nature." (Declaration in Defence of the Night Sky and the Right to Starlight).





## Nocturnal Landscapes

A night starry sky can be considered one the most awesome natural shows we can nowadays observe. Landscapes related to the night sky can feature incredibly different displays, where "landscape" denotes an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors<sup>4</sup>. The light of stars and other heavenly bodies has since always enriched terrestrial nature's display as well as human habitat, creating reference landscapes traditionally perceived by people as an integral part of their natural and cultural heritage.

At present it is necessary to preserve and put into value those areas where natural light still prevails, those places or environments characterized by the natural rhythm of the sun and moon cycles, clean air, and of dark nights unperturbed by artificial light. Under this view, these natural nightscapes, often associated with some kind of protected area, or left aside from intensive human occupation, should be considered as a resource able to uncountable experiences and perceptions of natural nocturnal landscapes.

Nightscapes can be very diverse, starry landscapes related to rural areas, urban oases, or sites associated with astronomical heritage which are worthy of special attention because of their increasing deterioration rate.

Application of the Starlight Reserve concept to this scope aims to protect and/or recover starlight-related landscapes, guarantee their quality, and establish the appropriate planning and management measures, where protection means action to conserve and maintain the significant or characteristic features of a landscape, including its associated natural, cultural and heritage elements.

*"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 skyscape, thus allowing them to guarantee the common right to contemplate the firmament". (Declaration in Defence of the Night Sky and the Right to Starlight).*

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<sup>4</sup> European Landscape Convention



## Intelligent Lighting and Climate Change

Light pollution has become a worldwide problem as it is gradually diminishing the capacity to observe the stars. This new kind of waste originates cultural, environmental and even energy impacts, with unforeseeable consequences.

The International Commission on Illumination defines light pollution as the sum of all adverse effects of artificial light in as much as they have an impact on the environment, including the direct impact of outdoor lighting and the brightening of the night sky that results from the reflection of radiation (sky glow). We can more precisely define light pollution as the light flow emitted at night by artificial light sources which are inappropriate in intensity, direction and/or spectral range, unnecessary to carry out the function they are intended for, or when artificial lighting is used in particular sites such as observatory, protected natural area or sensitive landscapes.

Among all causes having a negative effect on night sky quality, light pollution shows the highest immediate risks but, at the same time, it can be reduced through viable solutions. Irresponsible lighting includes over-illumination, which makes an excessive and unnecessary use of artificial light, as well as poorly designed luminaires which cause glare or sky glow<sup>1</sup>.

The common factor of these phenomena is the loss of the capacity to observe the stars, together with unnecessary impacts on people life quality, habitat deterioration and negative effects on wildlife. We must emphasize that less energy-consuming lamps emit a type of light which is more useful for humans and whose spectrum is not harmful for several animal species.

A Starlight Reserve would be an area where intelligent lighting systems are used, creating a reference and best-practice model which would allow eliminating or minimizing the negative effects of artificial illumination at night, limiting its use where it is necessary. Within Starlight Reserves, nocturnal lighting is designed to provide with the necessary visual information, avoiding light noise, energy waste, and excluding its use in areas which should be void of light intrusion. Their outdoor lighting policy aims to guarantee sky quality and people's and wildlife's right to the starlight.

Limiting the emission of particles into the atmosphere and promoting an intelligent, more energy efficient lighting system contributes to reach a double objective of fighting against climate change and recovering starry skies.

*"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, the lighting industry, and decisionmakers 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 strategy 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". (Declaration in Defence of the Night Sky and the Right to Starlight).*

1) Sky glow is a prime problem for star observation, because it reduces contrast in the night sky to the extent where it may become impossible to see all but the brightest stars.



## Starlight Destinations

Tourism, one of the most important and innovative activities on our planet, could act as the vector of a new alliance to promote the quality of the night sky.

Clear sky availability can rightly constitute an asset for the development of specific products geared towards scientific or cultural tourism. But we should not forget the potential value of a starry sky in any tourist destination, as an additional scenic element.

The firmament, as a scenario for tourism in modern times, has been present as a basic reference point in historical destinations. This vital resource has almost fallen into oblivion due to tourism's rapid development, standardising and massification. The present challenge is to reintroduce this resource as a basic part of the offer for those destinations which still have a chance to recover the clarity of their night sky.

At times, the starry sky and other nocturnal phenomena form part of the very essence of the tourism product, such as in the case of observations of the Northern Lights, visits to astronomical observatories, the sailing holidays featuring navigation by the stars, some pilgrimage routes, or the innovative visions offered by desert tourism at night.

The cultural heritage associated with astronomy acts as motivation for many travellers nowadays. At present, new big opportunities arise for many locations and destinations in which heritage is connected with astronomy, including archaeoastronomical heritage, being it a potential attraction for the development of sustainable tourism.

Astronomy sites and their surroundings are also candidate areas for the development of innovative and respectful tourism activities, where, with intelligence, visits can be made compatible with the careful protection of the extraordinary natural conditions at such locations, and their quality for astronomical observation.

Any Starlight area, as a responsible tourist destination, has the purpose to safeguard and put into value its night sky quality as well as to raise awareness among local population about the advantages that a dark sky can bring to their economy. If the right conditions are met, innovating tourist products related to astronomical observation, natural lightscapes and the associated cultural heritage can be successfully promoted.

*"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, the lighting industry, and decisionmakers 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 strategy 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". (Declaration in Defence of the Night Sky and the Right to Starlight).*



Several specific types of Starlight Reserves have been identified and defined. To date they cover the following categories:

- a) Starlight Heritage Sites
- b) Starlight Astronomy Sites
- c) Starlight Natural Sites
- d) Starlight Landscapes
- e) Rural and urban Starlight Oases
- f) Mixed Starlight Sites

#### A. STARLIGHT HERITAGE Sites

Archaeological and cultural sites or monuments created by man as an expression of its relationship with the firmament, which reflect the development of astronomy and its manifestation in the arts and traditions.

*They include:*

- Monuments or groups of buildings related to astronomy, of outstanding value from the point of view of history, art or science.
- Relevant sites and manifestations of cultural heritage related to sky observation, including archaeoastronomical sites.
- Areas where still survive expressions of tangible and intangible cultural heritage associated with astronomy, of particular importance for education in astronomy and the development of research on cultural heritage and sky observation.

#### B. STARLIGHT ASTRONOMY Sites

Exceptional observation sites characterised by outstanding sky astronomical quality which allow the development of advanced optical, infrared, and radio astronomy.

*They include:*

- Relevant astronomical observatories and their environment. Astronomical observatories by their nature are extremely sensitive to light pollution, as well as to atmospheric and radio electric pollution.
- Potential areas for advanced astronomical observation, recognised by the IAU and the international scientific community.
- Exceptional astronomical observation sites, whose characteristics give them a special interest for the development of educational and scientific activities or for the promotion and spreading of astronomy.

#### C. STARLIGHT NATURAL Sites



Natural areas whose ecosystem integrity and functioning, as well as the related biodiversity conservation, depend to a large extent on natural nocturnal light conditions.

*They include:*

- Habitats of particular relevance that host nocturnal wildlife species particularly sensitive to the loss of night sky quality or vulnerable to the effects of light pollution.
- Terrestrial and marine areas used as corridors and resting sites by migratory wildlife species whose habits and displacements could be affected negatively by glare or loss of natural sky brightness.
- Protected natural areas with a special relevance for the development of night-time environment research and management and the study of the natural patterns of light and dark.

#### **D. STARLIGHT LANDSCAPES**

Places where aesthetic manifestations of the night sky can be observed, as well as natural and cultural landscapes related to starlight where natural manifestations or human works beautifully blend with the view of the firmament.

*They include:*

- Areas where the starry sky, as well as exceptional manifestations of light-related phenomena can be observed with high quality and aesthetic strength.
- Expressions of nature and geological monuments associated to the firmament and related phenomena, which create night landscapes of acknowledged value.
- Cultural landscapes or expressions of combined works of nature and of man where the astronomical dimension prevails, as well as associative cultural landscapes related to starlight.

#### **E. Rural and urban STARLIGHT OASES**

Rural and urban areas free from the negative effects which impede star viewing and decrease night sky quality.

*They include:*

- Rural areas of outstanding singularity where the starry sky view is part of their recognised identity and values.
- Urban spaces or small cities keeping their night sky reasonably free from atmospheric and light pollution effects, where this resource is considered a social, environmental and citizens' cultural right.
- Tourist destinations considering the night sky an important resource, which committed themselves with the conservation of its quality and with the development of activities based on or related to astronomy and the enjoyment of the night sky.

#### **F. MIXED STARLIGHT Sites**

Sites that combine two or more of the previously described categories.





- To recover and conserve the cultural heritage related to astronomy and star observation.
- To preserve astronomy best sites as a common heritage, aiming at the development of science and the knowledge of the Universe, hence guaranteeing the benefits that are continuously originated by the advances of astrophysics.
- To maintain those areas with an exceptional starry night for public enjoyment, astronomy education, amateur astronomy observation, and artistic or aesthetic inspiration.
- To contribute to biodiversity conservation, protecting the species negatively affected by light pollution and maintaining the integrity of nocturnal habitats sensitive to sky quality degradation.
- To set the bases of an intelligent lighting culture that would allow the enjoyment of the night sky, minimise environmental impacts and make an efficient use of energy, limiting the negative effects on climate change.
- To open new windows to cultural and responsible tourism, taking advantage of starlight as a resource for the sustainable development of local communities.
- To integrate the night sky dimension in the World Heritage properties and the Biosphere Reserves, improving their functions and reach.
- To bring new dimensions to the management and conservation of protected areas, nighttime lightscapes and related cultural sites.
- To open new windows to research and science in all night-sky related domains.

Each Starlight Reserve should develop an Action Plan to formally state the active commitment in defence of the night sky and the right to starlight, where the main lines of action and the outlined objectives would be defined, according with the characteristics of each reserve. An ensemble of possible lines of action is listed here below as reference:

#### **Culture and Education**

- To identify and promote initiatives to enhance the value of tangible and intangible cultural heritage associated with astronomy, hence reinforcing our astronomy-related knowledge and retrieve firmament-related marks in local cultures.
- To identify actions aimed at conservation of astronomy-related cultural heritage.
- To develop research and dissemination actions regarding astronomy-related cultural heritage.
- To promote the astronomy and night-sky knowledge in education programmes.
- To promote artistic manifestations based on the defence of the quality of the night sky as a creative resource.
- To evaluate present-day indigenous artistic manifestations related to starlight.

#### **Astronomical observation**

- To identify the best sites for astronomical observation, as well as define the area to be preserved and the potential threats.
- To set up the appropriate measures to protect night sky quality in the best astronomical sites, considering this quality as a heritage to be preserved.
- To develop permanent educational and dissemination actions on astronomy, with the support of the scientific community and amateur astronomers.
- To develop awareness promotion initiatives for local population about the importance of astronomical observatories and the direct and indirect benefits generated by the development of astrophysics.

#### **Environment and biodiversity conservation**

- To identify those species and habitats which could suffer a negative effect from night sky quality loss and light pollution, as well as their distribution range.
- To set up programmes to increase knowledge and understanding of the scope of the ecological consequences of artificial light at night.
- To incorporate night sky quality and prevention of light pollution in the management plans of protected areas.

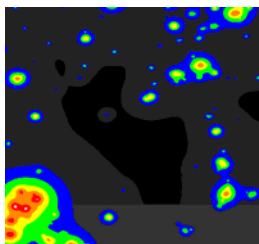
- To establish cooperation actions with other protected areas which include the maintenance of unperturbed night skies in their management and conservation strategies.
- To develop inventory & monitoring networks able to identify the state, evolution and effects of the night sky quality within the vital signs of protected (natural) areas.

### **Intelligent Lighting and Light Pollution**

- To develop laws or bylaws regulating the requirements of outdoor lighting to guarantee the protection of night sky quality.
- To incorporate measures in favour of energy saving and night-responsible outdoor lighting in the reserve's energy strategy definition and planning.
- To foment reference actions connected with intelligent illumination design, in both the architectural field and in urban planning, as well as in engineering, and the development of infrastructure.
- To strengthen local authorities' commitment for night sky defence in their choice of lighting systems, to ensure that "the public sector sets a good example".
- To promote labelling in recognition of lighting fixtures and products whose design aims to preserve the quality of night sky.
- To develop alliances with the main outdoor-lighting responsible actors, both public and private.
- To develop measures to avoid obtrusive light? to improve the quality of life of local populations.
- To inform local populations properly about the existing solutions, as well as of the environmental, personal and energy-saving benefits that a night sky respectful lighting entails.

### **Sustainable Tourism and starry skies**

- To identify night-sky associated resources aiming to develop scientific and cultural tourism related to astronomy.
- To promote the exceptional nocturnal skylscapes as basic resources in a new generation of tourist products.
- To establish alliances between tourist agents to preserve and put into value the tangible and intangible cultural heritage connected with astronomy and star observation as a tourism resource.
- To support the development of responsible tourist products related to astronomical observatories and non-professional observation sites of interest.
- To incorporate the clear sky criterion in the strategies of sustainable tourism destinations.
- To promote the inclusion of responsible lighting and night sky protection within the responsible tourism certification criteria and eco-labels.



### Core Zone

Within a Starlight Reserve, the core zone, or exclusion zone, is the unpolluted area/s where natural night sky light conditions are kept intact.

Core zones are conceived as true windows to the sky. They are areas where the night sky quality is extremely protected, to guarantee the Starlight Reserve basic functions related to starlight: observation, education, culture, habitat and sensitive wildlife protection, allowing at the same time the full enjoyment of starry sky landscapes by local populations and foreign visitors.

The core zone would include areas whose ratio between the artificial sky brightness and the natural sky brightness<sup>5</sup> is  $< 0.11$ . They correspond to Class 1 and 2 sites in the Bortle Dark-Sky Scale<sup>6</sup>.

### Criteria

A core zone is a dark area, void of any element that can cause light or air pollution.

The determination of sky quality, taking into account the key factors in each category, should be defined and monitored through reliable methods, by using measurements from both Earth and space.

In the case of areas where optical astronomical observation is the first activity, the protection of the site has to be maximised, taking into account that a 10% brightening of the night sky from artificial sources (relative to the natural sky brightness) results in an effective 10% smaller aperture for telescopes, and a corresponding loss of sensitivity and inability to do research. The installation and operation of radio communications stations are regulated, with a power flux density limit of  $W/m^2$  in force over the observatories<sup>7</sup>.

With regard to radioastronomy, radio interference limits should be established to ensure that equipment and measurements at the observatories are not corrupted<sup>8</sup>.

Nocturnal illumination conditions and natural clarity would be taken into account when dealing with sensitive habitats and wildlife species, as well as some factors that may have a negative effect on biodiversity conservation. Among others, the use of those isolated lights which can dazzle some species of animals (causing collisions), and of lighting systems emitting in a harmful range, such as ultraviolet radiation, which has an incontestable harmful effect on wildlife (insects, amphibians, fishes, mammals) will be avoided.

Lighting of monumental and cultural sites related to astronomy, necessary for interpretative and security reasons would be designed avoiding any impact on the quality of the night sky.

<sup>5</sup> Cinzano, P., Falchi, F., Elvidge C.D. 2001, The first world atlas of the artificial night sky brightness.

<sup>6</sup> Used as a reference in the Dark Sky Preserves classification (IDA).  
<http://www.skyandtelescope.com/resources/darksky/3304011.html>

<sup>7</sup> Power flux density for any frequency must not be greater than  $2 \times 10^{-6} W/m^2$  in any part of the observatories, equivalent to an electric field intensity of 88.8 dB ( $\mu V/m$ ).

<sup>8</sup> According to the recommendations of IAU – 50 Commission.

## Buffer Zone

It is the area that surrounds the core zone, protecting it from the possible harmful effects that could deteriorate its night sky quality. Buffer zones can include small human settlements and activity areas.

A buffer zone, or high sensitivity zone, will include the nearby area that can be directly seen from the core zone, creating a security belt which guarantees that the effects of air or light pollution would not affect the core zone.

### **Criteria**

The buffer zone is considered a high sensitivity area where the lighting systems are specifically designed not to interfere at all on core zone's clearness conditions, observational requirements and natural sky brightness. In the buffer zone all sources of air pollution that can have a direct or indirect negative effect on the core zone's night sky quality will be eliminated.

Buffer zones would also include the corridors of migratory and nocturnal species, particularly sensitive to light pollution, which connect with the core zone.

Within the buffer zones, night sky protection measures should also take into account the following outdoor lighting criteria:

- All lighting fixtures, both public and private, should focus their light emission on the area that needs to be illuminated, avoiding them being pointed towards the sky or the horizon, guaranteeing a high coefficient of utilisation (or utilisation)<sup>9</sup>.
- The luminaires should use optics appropriate for the elements to be illuminated and their location. Otherwise, screens or deflectors should be used to avoid light spilling out of the area.
- All lighting systems should avoid over-illumination, or excessive illuminance, complying with the recommended limits, taking also into account the effects of reflected light (illuminance)<sup>10</sup>.
- The use of outdoor lighting should be used only in hours when strictly necessary, especially in the case of road lighting, public areas, illuminated advertisements, commercial areas, parking and sport facilities. Time restrictions should be established according to the values and activities carried out in the core zone which could suffer a negative effect: astronomical observation, tourism, educational tours, research, and biodiversity conservation management.
- Total elimination of the use of sky beamers and laser floodlights.
- In the case of illuminated advertisements, a discreteness criterion should be used, checking the best orientation of the lights. Usage of high-pressure discharge lamps, light boxes and neon lights emitting above and towards the horizon should be avoided.
- In agreement with the energy saving criteria, outdoor lighting fixtures would always use the most efficient bulbs (see Chapter 8), whose contents of harmful materials are minimum. Their ultraviolet emission should be absent or minimum, because of its adverse environmental effects.

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<sup>9</sup>  $k \geq 30\%$  or  $u \geq 40\%$ .

<sup>10</sup> CIE/ISO Standards.



- Road lighting would be rigorously restricted to areas with justifiable needs. No road should be lighted outside city limits, except at intersections. The luminaire front glazing is kept at or near parallel to the surface. Their photometry would depend on the area to be illuminated. Asymmetric front luminaires should be used.
- Maximum discretion criteria will be established for monument, public building and ornamental lighting. Luminaires should always be oriented downwards, restricting the luminous flux to the object to be illuminated.
- Light trespass effects generated by outdoor lighting fixtures should be strictly limited.

Criteria for luminaires:

In the areas close to the core zone, the luminous flux emitted from a luminaire in the upper hemisphere should be zero (ULR<sup>11</sup> = 0).

In inhabited, areas less close to the core zone the following limits are established:

- Luminaires for roads: % ULR < 0,2
- Luminaires for streets: % ULR < 1,5 (Urban area)
- Luminaires for pedestrian use: % ULR < 2 (Urban area, shielded towards the core zone).

Luminaires should be installed without inclination, especially if they have a curved glass or a lenticular or convex, transparent glazing.

Buffer zones should entirely comply also with the general recommendations on responsible and intelligent lighting contained in Chapter 8. CIE's (International Commission on Illumination) recommendations on E1<sup>12</sup> category will be generally applicable in the buffer zone. Recommendations on E2<sup>13</sup> category will only be admitted within populated area not close to the core zone.

## External zone

When present, it corresponds to a general use area where existing larger human settlements could negatively impact on the night sky quality of the Reserve. It is an area close to the reserve where activities requiring a more intensive use of artificial lighting are developed.

The existence of this external or general zone is therefore subject to the presence of a larger populated area close to the Reserve, where sustainable practices aiming to safeguard the night sky quality should be implemented, limiting to the maximum the effects of air and light pollution.

### **Criteria**

The external zone is considered as a responsibility area where the measures of intelligent lighting and lighting energy efficiency have been generalised.

In these populated areas those lighting factors related to the loss of night sky quality or the protection of wildlife and landscapes would be taken into account, as well as those aspects

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<sup>11</sup> Upward Light Ratio of the Installation is the maximum permitted percentage of luminaire flux for the total installation that goes directly into the sky. In other words, it is the proportion of luminous flux emitted from a luminaire in the upper hemisphere.

<sup>12</sup> Intrinsically dark landscapes: national parks, areas of outstanding natural beauty, surroundings of observatories, etc.

<sup>13</sup> Low district brightness areas: rural, small village, or relatively dark urban locations...

directly or indirectly affecting the quality of life of population, such obtrusive light into houses and recreational areas.

The recommendations contained in Chapter 8 dealing with responsible and intelligent lighting, are applicable in the external zones.

***General criterion***

Within a Starlight Reserve, the commitment for the defence of the night sky quality and the right to starlight should be supported by a public-private commitment that would be formally stated through laws, by-laws, resource management plans or public-private agreements, to effectively guarantee the implementation of the specific criteria for each zone.

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The following general recommendations for outdoor lighting fixtures are established<sup>14</sup>. They are applicable throughout the Reserve, especially in populated areas or where some kind of activity is carried out. Night sky protection, rational use of energy, quality of life of local populations, as well as landscape and night wildlife protection are taken into account.

#### **How to plan an intelligent lighting system**

Before designing an intelligent lighting system responsible towards the quality of the night sky, or if we want to reverse the present effects of light pollution, we need to know:

- Where outdoor lighting is truly necessary and which useful service does it provide?
- How much lighting the areas and object to be illuminated need?
- Which unwanted effects can outdoor lighting lead to? Benefits and impacts.

After the above questions have been answered, the following recommendations should be used as a guide:

#### **Prevent the emission of light towards the sky or the horizon**

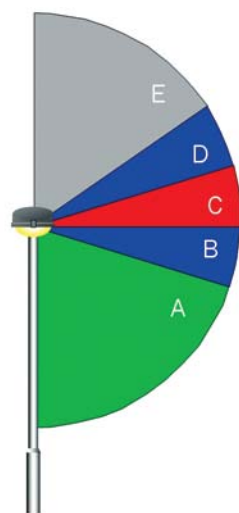
- Choose luminaires that direct minimal amounts of luminous flux to the sky. The selected luminaires should emit less than 2% of luminous flux above the horizon. Within the core zones and the most sensitive buffer zones, this parameter is reduced to 0.
- Use luminaires with reflectors and transparent, preferably flat or shallow bowl glass closing. Luminaires should not be inclined more than 10° in case of flat closing or 5° in other cases.
- Appropriate asymmetric luminaires should be used, without or with very little inclination (less than 10°) or, in exceptional cases, symmetric ones provided with ant-glare screens or deflectors.
- When choosing roadway luminaires, the proportion of light emitted along the street side of the road should be maximized and the proportion emitted on the house side minimized.
- Avoid directing luminaires at angles greater than 70° (maximum intensity direction), to prevent direct glare and light trespass.

#### **Prevent lighting and luminance effects so that photometric distribution is effectively adjusted to needs.**

- In order to establish the necessary lighting levels for public areas, buildings monuments and light signs, follow the regulations, national laws, recognised international directives, and recommendations of International Commission on Illumination (CIE), in particular those aiming to prevent light pollution effects.
- Responsible manufacturer's or prestigious institution's published recommendations should be used. The minimum level figures set by these documents should be considered as recommendations.

<sup>14</sup> These recommendations are based on the study developed by the OTC (Oficina Técnica de Protección del Cielo) of IAC (Instituto de Astrofísica de Canarias).

- Support lighting level reduction or even light turn-off at a certain hour at night in accordance with its usefulness.
- Use high-performance luminaires whose light beam is adapted to the surface to be illuminated, to illuminate only the needed area, and whose design has a high coefficient of utilization ( $K > 0,3$ ).
- Avoid the domino effect, which leads to lighting in excess new areas only because the existing ones were over-illuminated. These existing over-illuminated areas should be corrected before designing new installations. Competition and wish to stand out some installations on others, exaggerating the lighting levels used, which may lead to an uncontrolled and unnecessary escalation of the energy consumption caused by human eye behaviour.
- Do not design installations with exaggerated lighting levels in socially conflictive areas. There is enough information available demonstrating that security and over-illumination do not go hand by hand.
- Light pollution has increasingly become a major concern as an environmental impact of transportation facilities. In most populated areas it can be stated that 50% of light pollution is produced by roadway lighting. Therefore, the enforcement of responsible lighting criteria should be maximised in these areas.



#### Effect on Skyglow and cut-off angle<sup>15</sup>

Diagram to show relative impact of a luminaire's output contribution to skyglow.

E - 100-180° Critical area for skyglow experience from within urban and all areas but proportionally less impact to rural areas.

D - 95-100° Significant contributor to skyglow, especially in rural areas where it is most aerosol dependent. Less likely to be obstructed.

C - 90-95° Critical zone for skyglow and obstruction seen at 10s of km (in rural areas) where it is strongly dependent on aerosol scattering.

B - 85-90° Significant contributor to skyglow seen at a distance through reflection but reflected light more likely to be obstructed by buildings, trees and topography.

A - 0-85° Ideal light distribution.

#### Save energy and protect the environment

- Always choose the most energy-efficient bulbs.
- When the chromatic performance of an installation is not a major objective, use the bulb/luminaire assembly that gives the most efficient illumination in terms of  $W/m^2/lux$ .
- Choose light bulbs whose spectrum has the lowest impact on sky glow and on night sky quality in general. Reflection of air borne particles and diffusion by the atmosphere make artificial light visible in the sky. Diffusion increases as the wave length of light decreases. Therefore, white light is the most harmful for night sky quality. Yellow light is more diffused than red light but less diffused than blue light. The most effective way available at present to reduce this negative impact is the use of monochromatic or quasi-monochromatic light sources, such as low-pressure sodium lamps. These lamps emit a very narrow spectral band, almost a line, in the yellow part of the spectrum.

<sup>15</sup> Chris Baddiley. British astronomical Association - Campaign for Dark Skies.

- Avoid the use of lamps emitting a large amount of ultraviolet radiation<sup>16</sup>. This type of lamps attracts up to three times more insects than sodium vapour lamps, leading to an important loss in biodiversity whose effects can reach 1 km distance. Negative repercussions of ultraviolet radiation on human health are also well known. As a general criterion, lamps emitting below 480 nm should be avoided.

Types of light bulbs – Chromatic characteristics and efficacy		
Type of bulb	Colour	luminous efficacy (lumen / W)
Low-pressure sodium (HPS)	yellow	180 – >200
High-pressure sodium (HPS)	rose / amber yellow - white	90 - 130
Metal halide (MH)	cool white / warm white	60 -120
Compact fluorescent (CFL)	white	45 -60
Mercury vapour (MV)	greenish blue / white	13 - 48
Incandescent/ Halogen	yellow/white	8 - 25



Spectrum of a low-pressure sodium lamp



Spectrum of a high-pressure mercury lamp

### Recommendations on the limitation of intrusive light

Recommendations contained in the "Guide on the limitation of the effects of obtrusive light from outdoor lighting installations" (CIE 150:2003) are applicable, in particular those approaching the parameters of illuminance and luminous intensity emitted by luminaires, with regard to reserve zoning (E1 – E2 in sensitive areas of the Reserve).

### Lighting of roads for motor and pedestrian traffic

"Recommendations for the lighting of roads for motor and pedestrian traffic" (CIE-115-1995), which establish average and maximum values of luminance, are applicable.

The "Guide to the lighting of urban areas" CIE-136-2000 includes recommendations to limit luminaire brightness to avoid glare, setting maximum values according to the luminaire fixture height.

### Recommended illumination levels for luminous signs and advertisements

Those contained in the "Guide to the lighting of urban areas" (CIE 92 – 1992) are applicable.

For sensitive areas within the reserve, (buffer zone), the recommendations contained in the "Guide on the limitation of the effects of obtrusive light from outdoor lighting installations." (CIE 150–2003)

<sup>16</sup> e.g.: high pressure mercury lamps.



related to this section would be taken into account, and in particular the one establishing limits according with zonation, that in this case would have a maximum value of 50 cd/m<sup>2</sup>.

#### **Recommended levels for building façades and monuments**

Those contained in the Guide from CIE Technical Committee TC 5-06, which provides information on how to use exterior lighting for the decoration of the nighttime urban landscape (CIE 94 – 1993). This guide recommends a maximum luminance value of 4 cd/m<sup>2</sup> in inhabited areas similar to those allowed in the buffer zones, never exceeding 6 cd/m<sup>2</sup>.

Maximum brightness values allowed (cd/m<sup>2</sup>) for illumination of building façades and monuments, according to the zonation, are also contained in the "Guide on the limitation of the effects of obtrusive light from outdoor lighting installations." (CIE 150–2003), where maximum values for areas similar to the external zone (E3) are of 10 cd/m<sup>2</sup>.

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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 civilizations, 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 the 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 which govern the universe, and that the interest in astronomy has had profound implications for science, philosophy, culture, and our general conception of the universe;

*Recognizing* 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 generalized 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 barrier 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 protection 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 untainted skies, and are entitled to enjoy these as the basis 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, which together 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;

*Attentive to* the urgent need to establish efficient alliances among the leading players, whose decisions can have an influence on reversing the process of degradation 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, decisionmakers, 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 and 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 that the main problems concerning resources and the environment are addressed.

**3** The conservation, protection, and revaluation of the natural and cultural heritage associated with nocturnal landscapes and the observation of the firmament represents a prime opportunity and a universal obligation for cooperation in safeguarding the quality of life. For all decisionmakers, this attitude implies a genuine challenge involving cultural, technological, and scientific innovation, requiring a major constant effort to enable everyone to rediscover the presence of the night sky as a living part of the heritage of mankind.

**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 nocturnal 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 skyline, 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, the lighting industry, and decisionmakers 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 strategy 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 nocturnal skyscape. Responsible tourism can and should take on board the night sky as a resource to protect and value in all destinations. Generating new tourist products based on the observation of the firmament and the phenomena of the night, opens up unsuspected possibilities for cooperation among 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 to include the protection of clear night skies as a key factor strengthening their mission in conserving 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.

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## Units and acronyms

**candela** [cd] - is the SI base unit of luminous intensity. Power emitted by a light source in a particular direction.

**lumen** [lm] - is the SI unit of luminous flux, used to describe a quantity of light emitted by a source or received by a surface.

**lux** [lx] – is the SI unit of illuminance and luminous emittance. 1 lx= 1 lumen /m<sup>2</sup>.

**SI** - International System of Units.

**ULR** - Upward Light Ratio of the Installation is the maximum permitted percentage of luminaire flux for the total installation that goes directly into the sky.

## Concepts

**Curfew** - The time after which stricter requirements (for the control of obtrusive light) will apply; often a condition of use of lighting applied by the local planning authority.

**Glare** - Glare is often the result of excessive contrast between bright and dark areas in the field of view.

**Illumination** - The application of visible radiation, or light, to an object.

**Illuminance** - (or illumination level) is defined as the amount of light being transmitted upon a certain area. The unit for illuminance is the lux, which is equal to one lumen per square meter [lm/m<sup>2</sup>].

**Light noise** - Light that does not transmit significant visual information.

**Light pollution** - is excess or obtrusive light created by humans.

**Lightscape** - The total environment created with natural and/or artificial light.

**Luminance** - Luminance is the brightness of an object that has been illuminated by a source.

**Luminaire** - An apparatus which controls the distribution of light given by a lamp or lamps and which includes all the components necessary for fixing and protecting the lamps and for connecting them to the power supply. Colloquially a 'lighting fitting'.

**Luminous efficacy** - The ratio of light emitted, to the power consumed by a lamp. [lm/W].

**Nightscape** - A nocturnal scene considered together with all the elements and features constituting it.

**Over-illumination** - excessive use of light. Presence of lighting intensity (illuminance) beyond that required for a specified activity.

**Photopollution** - Alteration of natural light regimes.

**Sky glow** - Sky glow is caused by light that shines upward and is scattered off dust and aerosols in the lower few kilometres of our atmosphere. It is seen at a great distance as the dome of light over urban areas.

**Skyscape** - A view, landscape or representation of the sky.

**Utilance** - The proportion of luminous flux emitted by a luminaire which reaches the working plane.



# Working Meeting / Participants

UNESCO HQ, Paris, World Heritage Centre

10 / 15 /19 October 2007

**Participants :**

**« Astronomy and World Heritage » & Starlight members:**

1. Prof. Alexander Boksenberg, Chairperson, UK National Commission for UNESCO
2. Sr. D. Luís Ramallo Massanet, Chairperson of the Spanish National Commission for UNESCO
3. Mr Miguel Clusener-Godt, Ecological Sciences and Biodiversity Section SC/EES/ESB
4. Mr Cipriano Marin, Coordinator Starlight Initiative (IAC).
5. Ms Anna Sidorenko-Dulom, Coordinator Astronomy and World Heritage Initiative, CLT/WHC
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7. Mrs Mechtild Rossler, Chief Europe & North America Section, CLT/WHC/EUR
8. Ms Celine Fuchs, CLT/WHC/EUR
9. Ms Ekaterina Lichtenstein, CLT/WHC/EUR
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**Advisory Bodies of the World Heritage Committee:**

11. Mrs Regina Durighello, Director World Heritage Programme, ICOMOS

**IAU**

12. Prof. Karel A. van der Hucht, General Secretary International Astronomical Union
13. Prof. Richard Wainscoat, President IAU Commission 50, University of Hawaii

**State Parties representatives and experts :**

14. Ms Margaret Austin, former Chairperson of the New Zealand National Commission
15. Ms Mandy Barrie, Head of Policy, Strategy & Resources Unit, UK Department for Culture, Media & Sport
16. Dr Christopher Young, Head of World Heritage and International Policy, English Heritage, UK Department for Culture, Media & Sport
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