

Light pollution in Valencian Natural Parks: where light not only annoys astronomers

Enric Marco^{1,4}, Angel Morales Rubio^{2,5}, and Joan Manuel Bullón^{3,4}

¹ Departament d'Astronomia i Astrofísica, Universitat de València

² Departament de Química Analítica, Universitat de València

³ Agent Mediambiental-Cap de Zona, Conselleria d'Infraestructures, Territori i Medi Ambient, Generalitat Valenciana

⁴ Agrupació Astronòmica de la Safor

⁵ Coordinadora en Defensa de los Bosques del Turia

Abstract

Street lighting of the city of Valencia produces a yellowish halo that prevents astronomical observation. Moreover, within the metropolitan area, there are three natural parks: the Parc Natural de l'Albufera, the Parc Natural del Túria and the Parc Natural de la Calderona. The light pollution affects the nighttime wildlife parks. Therefore, since 2010, a campaign is being carried out in order to collect data but also to raise awareness and reporting of the harmful effects of excessive and incorrect installation of existing luminaires. Since 2012 this study has been extended to other Valencian natural parks far from Valencia. Their sky darkness is a value to preserve.

1 Introduction

Light pollution not only affects astronomical observation. It is internationally well reported that excessive number of artificial light points radiating indiscriminately in all directions exerts strong effects on the wildlife that lives around night and light cadence. The Valencian parks are very affected by the problem, and apart from the Parc Natural de l'Albufera, no rigorous study has been done to date on them.

The Parc Natural del Túria suffers great urban pressure due to its proximity to the Valencia metropolitan area. Pollution caused by light excess affects the environment inside and outside the park. Since 2010, an intensive data collection campaign and the presentation of the results in an international conference [1], as well as the report, awareness and dissemination in the media and in civil society are starting to achieve some results as the recent

passage of the Light Pollution Prevention Ordinance [2] in the city of Paterna, the main town of the park with 66,000 inhabitants.

Currently measurements of the night sky brightness have been spread to other natural parks and areas of interest away from the Valencia metropolitan area to assess, firstly light pollution and then see how animal and plant populations are affected .

The studied parks in this work are: Parc del Túria, Serra Calderona, Chera-Sot de Chera and Puebla de San Miguel and the areas of natural interest, Castellfort (els Ports), Serranos region and the Ombria del Benicadell.

2 Awareness and report

Light pollution is basically a problem of public awareness. This is the reason why the results have been disseminated in towns near natural parks through talks followed by an astronomical observation, after lighting off the street lights. To date, these activities have been done in Pedralba (November 2011), Gandia (December 2011), Riba-roja de Túria (June 2012), Beniatjar (July 2012), Sot de Chera and Chera (August 2012), Paterna (October 2012) and València (November 2012).

In addition there have been proposed motions against light pollution in all populations of the Parc Natural del Túria, which have been approved in a plenary session by Manises, Riba-roja de Túria and Paterna City Councils. Finally, in this latter town we have assisted in the preparation of its Light Pollution Prevention Ordinance [2].

But the grievous non-observance of the light regulations like new lighting balloons in a social center and unshielded projectors at Manises airport, València, have been reported to the Ombudsman and to the Government of Spain through the Congress of Deputies respectively.

3 Experimental procedures

In every natural area we have visited their highest summits accessible through forest roads using a 4x4 car in order to view, as far as possible, all the sky free from obstructions and allow to survey the sources of light pollution.

Light pollution values were obtained using the standard portable equipment SQM-L provided by Unihedron that yields light data in mag arcsec⁻² units, commonly used in astronomy. Measurements were made during moonless nights and more than an hour after sunset ($h_{\odot} < -18^{\circ}$).

As night came at the chosen high locations, readings of the night sky brightness were taken at the zenith direction using our equipment during 60 minutes with intervals of few minutes to obtain the light curve variation. In addition to these measurements at the zenith, readings were also taken along the 360° in azimuth in eight directions at the altitude 45° and at the horizon to the North (N), South (S), East (E) and West (W) and at intermediate positions Northeast (NE), Northwest (NW), Southeast (SE) and Southwest (SW). These 17 values are graphically presented in the shape of two concentric circles (0° and 45°) and a

central point corresponding to the zenith (90°).

Using the SQM-L brightness of the full moon or of nearby artificial lighting we obtain values around $16 \text{ mag arcsec}^{-2}$. However, with a good quality dark sky, the SQM-L reaches values equal to or greater than $21 \text{ mag arcsec}^{-2}$.

4 Parc Natural del Túria

As the natural park is embedded within the metropolitan area of Valencia, measures towards the horizon shows the minimum values of mag arcsec^{-2} . But due of its 35 km long along the Turia river the values improve as we move away from Valencia. The results obtained in Carasols, just in front of the airport, and at the Vallesa forest located between Paterna and L'Elia, show values between 15.5 and 17.0 to the East, Southeast and South, strongly imply a totally degraded sky.

The other two studied locations, Les Rodanes and La Pea, being further away, reach higher values, 16.8 to $18.9 \text{ mag arcsec}^{-2}$ to the E-SE-S directions. Industrial areas around the A3 freeway towards the SE-S are the main sources of pollution.

At 45° the night sky brightness shows values from 18 to $19 \text{ mag arcsec}^{-2}$ towards Valencia metropolitan area.

Finally, the values obtained just at the zenith of the three studied areas improve as we move away from the capital and the A3 freeway. If at the Carasols and the Vallesa forest we obtained 18.95 and $18.44 \text{ mag arcsec}^{-2}$ respectively, the data greatly improve at Les Rodanes forest up to $19.04 \text{ mag arcsec}^{-2}$ and achieve $20.35 \text{ mag arcsec}^{-2}$ at La Pea forest. It is in this latter zone where the dark sky allows astronomical observations.

During this last two years we have studied the characteristics of lighting of the lamps used in the neighboring towns. The ornamental lighting of monuments like the church of Riba-roja, sports centers, quarries, roundabouts and the water and power plants are the main sources of pollution in the vicinity of the park.

The "Earth Hour", a world citizens' initiative to send a powerful message for action to save the planet took place on March 31, 2012. The main public buildings in Valencia turned their lights out for one hour to take a stand against climate change. However, measures taken with the SQM-L clearly indicate that this initiative has little effect in relation to the reduction of light pollution, as it was done a week after the daylight saving time change and therefore it was not completely dark.

The first results concerning this park have been presented in a dark sky international meeting [1], at a University exhibition, and in a book [3] about Valencian natural parks published by the Universitat de València.

5 Parc Natural de la Calderona

This park is located north of the city of Valencia. At the five studied locations, measurements taken towards the horizon in S-SE-SW directions, show low values due to the metropolitan

Table 1: Sample of light pollution data in natural parks (zenith)

Natural Parks	Places	Date	$mag\ sec^{-2}$
PN del Túria	Carasols	20.05.2011	18.95
	La Vallesa	15.06.2011	18.44
	Les Rodanes	21.06.2011	19.04
PN de la Calderona	La Pea	26.05.2011	20.35
	Rebalsadors	22.03.2012	20.38
	Alt del Pi	16.04.2012	20.06
	Garbí	11.04.2012	20.10
	Mirador de l'abella	22.03.2012	20.23
PN de Chera-Sot de Chera	Pic de l'Àguila	09.05.2012	20.55
	Pico Terrac	15.05.2012	20.95
	TV antennas	21.06.2012	21.12
	Pico Cinco Pinos	23.05.2012	21.13
	Casa forestal	22.06.2012	21.23
PN Puebla de San Miguel	Pico Ropé	14.05.2012	21.35
	Pico el Gavilán	21.08.2011	21.32
	Aras de los Olmos	Muela de Santa Catalina	04.08.2011
Ombria del Benicadell	Observatori meteorològic	20.06.2012	20.51
Castellfort	Santuari	22.06.2012	21.55

area of Valencia, the harbor, the airport and the town Port de Sagunt. Northeast, small existing populations contribute little to the light pollution, as well as the contribution from the NW is even lower.

At 45° , the farther from the metropolitan area of Valencia we are the lower the dark sky brightness is. Finally, results at the zenith of the five considered sites shown values above $20.00\ mag\ arcsec^{-2}$. It is remarkable that the sky quality improves at the farthest point from Valencia (20.55, pic de l'Àguila).

We have also studied the type of lighting of the lamps used in the neighboring towns. In some of them we found an incorrect public lighting that can clearly be improved. Some examples of these problems can be found at Serra, where monumental lighting points directly to the sky, or at Nàquera, with strange streetlights that produce glare. Inside the natural park, there is a location where TV antennas shine permanently during the night.

The unshielded lighting of the Fallas has been revealed as an important source of light pollution. This effect has been determined, for the first time, by measuring during and after Saint Joseph's festival. In Rebalsadors, the dark sky brightness at the zenith direction diminishes a 57% and up to 151% to 45° altitude towards Valencia when the Fallas lighting is turned off.

6 Parc Natural de Chera-Sot de Chera

As in the previous case, the horizon values show higher light pollution. The low values in the S-SE-E directions indicate the location of the towns that contribute more to the loss of the night sky: Valencia metropolitan area, airport and harbor, Port de Sagunt and

the urban areas of Camp de Túria region. At the remaining directions the populations contribute little to light pollution. However, from the Cinco Pinos summit, the white lighting of the TGV railway station, towards SW, is clearly visible. When comparing the dark sky brightnesses, this light source ($18.76 \text{ mag arcsec}^{-2}$) contributes twice the entire metropolitan area of Valencia spotted towards SE ($19.53 \text{ mag arcsec}^{-2}$).

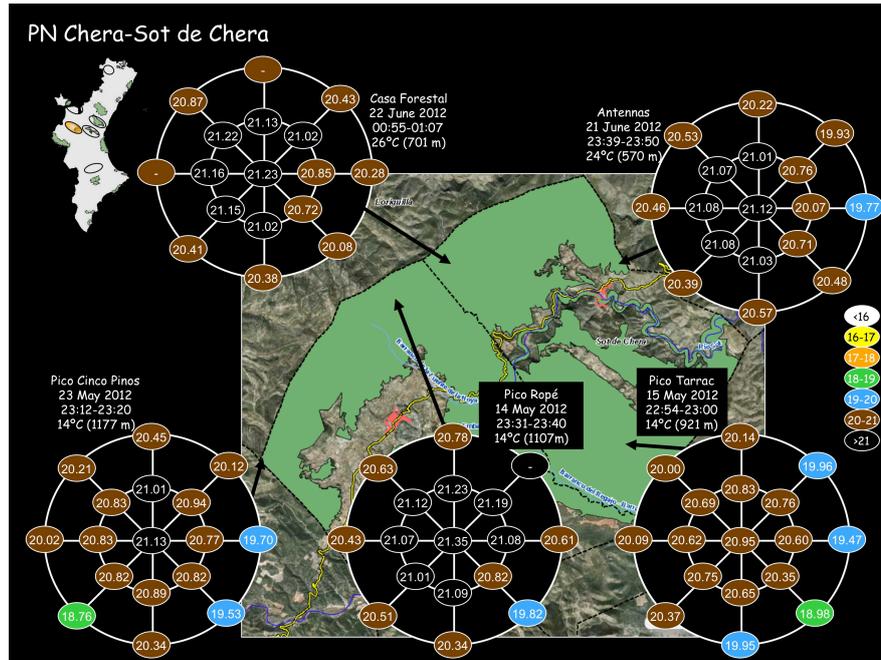


Figure 1: Light pollution data obtained in the PN de Chera-Sot de Chera. It is worth mentioning the dark skies and the necessity to preserve them.

At 45° , light pollution decreases away from Valencia. In any case, all studied locations reveal extraordinary night sky.

Finally, at the zenith, four of the five measured positions show values above $21.00 \text{ mag arcsec}^{-2}$, confirming the exceptional sky park quality for what it is worth preserving it from any possible future light aggression. Even at Pico Tarrac, closest to the area of Valencia, the zenith value achieves $20.95 \text{ mag arcsec}^2$, a quantity allowing a clear observation of the Milky Way.

Note that the two small towns inside the park contribute very little to the dark sky brightness. Even a few hundred meters away from urban areas we are able to spot the Andromeda galaxy and some nebula with a naked eye.

7 Other natural sites

We have studied other areas of natural interest as Serrania, Alt Túria (els Serrans), Puebla de San Miguel (Rincón de Ademuz), Javalambre (Teruel). All obtained values exceed 21

mag arcsec⁻² at both the zenith and at 45° altitude what it is very suitable for astronomical observation and environmental protection. In fact, it is not by chance that the Observatori Astronòmic de la Universitat de València, the Centre Astronòmic de l'Alt Túria of the Associació Valenciana d'Astronomia, the Observatori La Cambra are settled in the area near Aras de los Olmos while the new CEFCA telescopes are located in Javalambre.

The values obtained in Castellfort (els Ports) are also greater than 21 mag arcsec⁻² at the zenith and at 45° altitude. In this area, a bat colony, very sensitive to light pollution, can be found.

L'Ombria del Benicadell, despite being in the southern part of the populated region Vall d'Albaida, is a fairly dark place. Data taken at the zenith and at 45° altitude were greater than 20 mag arcsec⁻² in the meteorological observatory and at various locations of the mountain range. The nearby towns are small and less polluting. The Beniatjar roundabout is the brightest spot on this natural environment.

8 Conclusions

There are still natural places with a really dark sky (>21 mag arcsec⁻²). These should be protected for possible future light aggression, like white LEDs or flashing white projectors usually installed at the wind turbines. These areas are far from big cities and are favorable environments to nocturnal animal and plant life. Chera-Sot de Chera, the Serrania and Castellfort area pay particular attention for their obscurity.

The Falles festival lighting increases light pollution. "Earth Hour" initiative has little effect with respect to the reduction of light pollution.

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