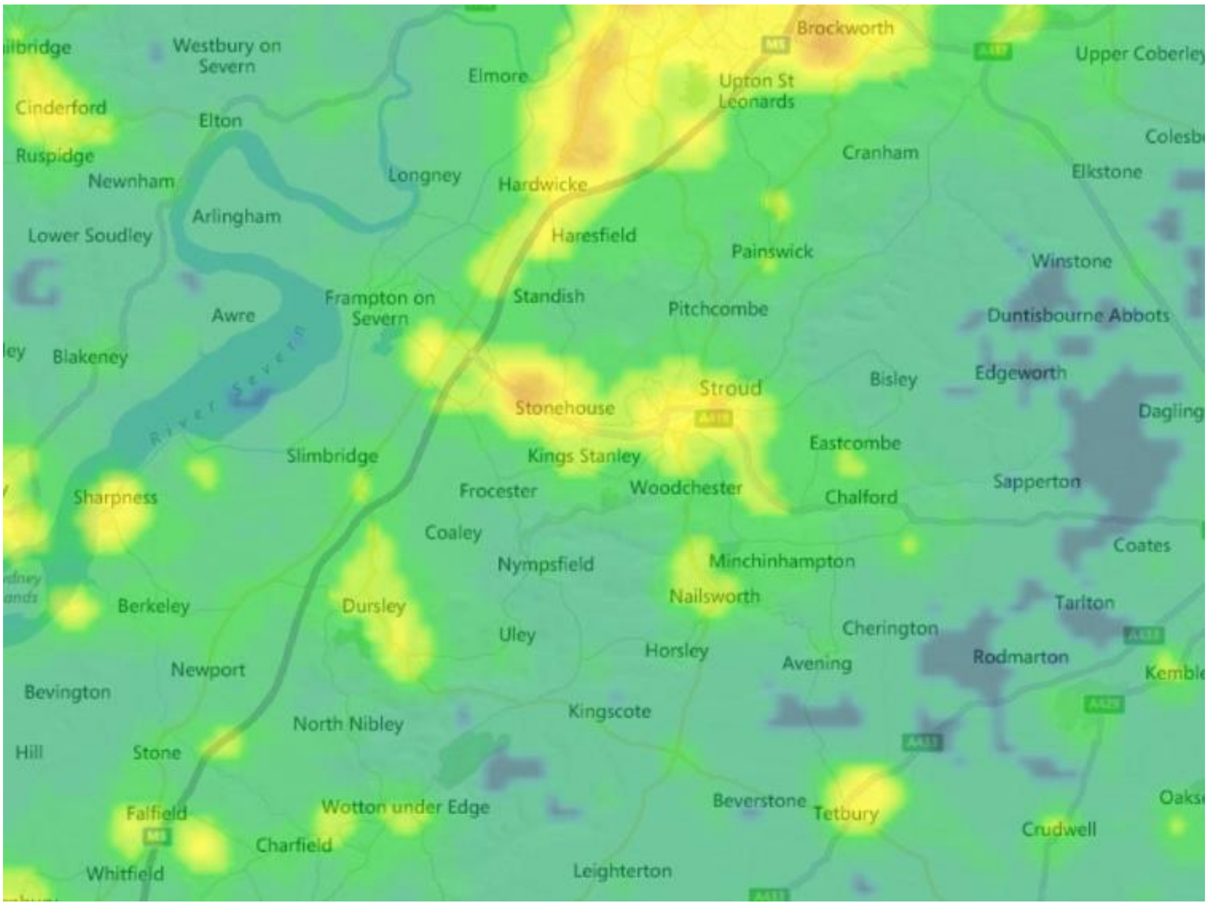
The following relates primarily to these aspects of the Plan: Priority Issues, namely conserving and enhancing Stroud District's countryside and biodiversity (page 14) and Core Policy CP14, item 2, no unacceptable levels of light pollution (page 178). These factors are related because preserving biodiversity is dependent upon preserving a dark night-time environment.

The picture below shows the distribution of upward spill of light at night across Stroud District, obtained from Suomi NPP satellite VIIRS data for 2019 (https://www.lightpollutionmap.info).



The following is evident from the picture:

- All major towns and villages within Stroud District can be detected by the satellite. An interesting example where this is not the case is Bisley, noting its lack of significantly sized businesses and its policy to not illuminate its streets.
- The easternmost area of the AONB within Stroud District is close to being naturally dark, however light levels generally increase from east to west.
- Three 'hotspots' of upward light spill, coloured dark red/brown, lie within Stroud district: Stroud, Hardwicke and the industrial area at Stonehouse.
- Two of these hotspots, Stroud and the industrial area at Stonehouse, lie within or border the Cotswolds AONB.
- Other industrial areas are also detected by the satellite, such as the area around Junction 13 of the M5 (e.g. near Frampton on Severn).

VIIRS is not especially sensitive to blue light and so the data under-represents emission from modern light sources such as white LEDs and metal halide lamps, each of which has a significant blue component to their light output. These types of lamps are now used extensively for the lighting of streets, industrial areas, businesses, car parks, sports pitches etc. and this is an important factor because:

- Blue light scatters through the atmosphere more effectively than other colours, making its presence apparent over larger distances (as evidenced by the blue daytime sky).
- It follows that blue emission from white LEDs and metal halide lamps scatters from towns and villages into neighbouring countryside more effectively than 'warmer' coloured light, such as amber light.
- Photosensitive retinal ganglion cells (pRGCs) in the human eye and equivalent cells in other animals are especially sensitive to blue light and relatively insensitive to other colours; pRGCs signal the entrainment of circadian rhythms in other cells in the body, e.g. cells in the pancreas, liver etc. and regulate sleep patterns.

Risks

Aside from degrading the natural astronomical environment, light pollution and associated skyglow is believed to impact ecological systems in various ways:

- Biological timing (e.g. circadian rhythms, reproduction).
- Vision (e.g. colour sensitivity, de-sensitisation, loss of contrast, glare).
- Spatial and temporal disorientation (e.g. movement into inappropriate habitat, movement at the wrong time).
- Predation (e.g. increased susceptibility to predation, reduced scope for predation).
- Attraction (e.g. decreased interaction affecting mating).

The impact of the above upon biodiversity is a matter of ongoing research although it is now broadly accepted that artificial light at night generally has a negative impact upon biodiversity.

Stroud District Local Plan and Lighting Requirements

The adverse impact of artificial lighting at night can be reduced by applying available engineering solutions which satisfy the following requirements and which could be enforced via the planning process. The following list constitutes an overview of the type of requirements which should be specified:

- Lamps should have appropriate optics and shielding so that no light is emitted directly beyond the target area, e.g. no light should be emitted directly beyond the site boundary of a business, industrial park, sports pitch etc. This is to prevent direct light infringement upon neighbouring habitats.
- Lamps should not emit light above the horizontal plane passing through the lamp. Computer modelling and experiments demonstrate that low-angle emission above such a plane can make a significant contribution to skyglow.
- Lamps should only be switched on at full rating when required and should otherwise be switched off or dimmed significantly. This is to minimise energy consumption and infringement upon neighbouring areas by indirect means, e.g. reflection from surfaces

and buildings. Motion sensing technology and central control systems provide the means of satisfying this requirement.

- Numerical targets and upper limits for lighting levels (e.g. illuminance, measured in lux) should be specified for illuminated surfaces. Any limit should correspond to a ‘minimum standard’ for protecting the environment. However, satisfying a given limit might not correspond to an optimised solution and so a (lower) target value should also be specified with the expectation it will also be satisfied unless the contrary can be justified by the lighting scheme designer (to the satisfaction of the planning authority). For example, the International Dark-sky Association (IDA) specifies an upper limit for illuminance equal to 25 lux for many situations; this could be supplemented by specifying a target illuminance of 5 lux, say, placing the onus on the lighting scheme designer to justify why 5 lux is not achievable (if such were believed to be the case).
- Similarly, lamps emitting light of a ‘psychologically warm colour’ should be used instead of those having a ‘cool colour’. It is common for Correlated Colour Temperature (CCT) to be specified as a surrogate indication of the ‘psychological colour’ of a lamp. Current evidence suggests that a target CCT of 2300K should be specified along with an upper limit of 3000K which should not be exceeded. [Note the specified CCT is converse to psychological colour; a lower CCT value implies a warmer colour, psychologically speaking.]

Evidence from other LPAs

Regardless of the details of the lighting requirements chosen, plenty of experience within the UK context now exists regarding how to specify lighting requirements so as to constrain the amount of light straying upwards and sideways into the wider environment:

Cranborne Chase AONB (note the reliance upon the participation of several LPAs):
https://darksky.app.box.com/s/l6fgl7666an3huhdtycmylhv36nftf40

Brecon Beacons National Park:
https://darksky.app.box.com/s/zzg0kwfhk4ivf5gxoclv72q5i5nbatmd

Snowdonia National Park:
https://www.darksky.org/wp-content/uploads/2015/11/Snowdonia_IDSR_lighting_plan.pdf

It is noted that some of the local Parish Councils either have or are developing policies to reduce light pollution (e.g. Minchinhampton, Bisley-with-Lypiatt, Amberley) although these don’t contain numerical limits or targets, may not be consistent with each other and are not easily enforceable. Hence it is considered necessary that in order to underwrite the claim of conserving and enhancing biodiversity, a lighting policy of the kind outlined above (or presented via the above links) should be introduced at the District level.

Further Reading

Below is a small selection of articles that underpin the above text. Other similar studies may be found in the scientific literature and online.

An overview of pRGCs and their discovery:
https://www.cell.com/current-biology/pdf/S0960-9822(07)01685-5.pdf

Peak spectral sensitivity of pRGCs (melanopsin pigment) occurs in the range of 440nm to 500nm, broadly speaking, and peaks at 479nm in this study (corresponding to blue light). See Figure 3:
https://royalsocietypublishing.org/doi/pdf/10.1098/rspb.2012.2987

Typical white LED spectrum showing peak emission at 465nm (overlapping the peak spectral sensitivity of pRGCs):
https://en.wikipedia.org/wiki/Light-emitting_diode#/media/File:White_LED.png

“Light pollution is a driver of insect declines” and references therein:
https://www.sciencedirect.com/science/article/abs/pii/S0006320719307797?via%3Dihub

Impacts of artificial lighting upon biological timings:
https://www.annualreviews.org/doi/abs/10.1146/annurev-ecolsys-110316-022745

Specific example of artificial lighting affecting moths (a pollinator) and references therein:
https://royalsocietypublishing.org/doi/pdf/10.1098/rsbl.2016.0874