Lightshed Management: A Regional Approach To Light Pollution Control

Theme: Governance & Regulation

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Regulatory models for controlling light pollution over large geographical areas have historically taken either top-down or bottom-up approaches implemented on (sub-)national or local levels, respectively. But these methods have failed to stem the rising and virtually unchecked global tide of outdoor artificial light at night (ALAN) emission.

We speculate that policy interventions at the middle level may be more effective in terms of measurably reducing light pollution. This involves a balance of local input and control through policies that act on large, multi-jurisdictional scales. We are inspired by the principles of regional watershed management. This method is informed by the concept of network governance where stakeholders form partnerships with the goal of establishing a common vision for the management of a resource that is simultaneously viewed as an economic good and a social good.

As the watershed is the land area that channels all surface and subsurface water toward common outflow points, we conceive of a "lightshed" as the geographic territory over which the outdoor ALAN emissions of cities and other sources are distributed. In this we build on radiative transfer modeling efforts demonstrating the spatial transmission of light pollution between different territorial areas. These results demonstrate the inadequacy of a municipality-by-municipality light pollution control framework given that ALAN readily drifts across multiple political boundaries from source to sink. The watershed analogy demonstrates the need for concerted and coordinated efforts in both the vertical and horizontal directions of the jurisdictional hierarchy.

In our model, groups of governments in a territory first agree to seek a solution to light pollution. They commit to a quantitative goal of reducing light pollution by some measurable amount in a defined period of time. That goal can be set relative to metrics such as light emissions per capita within the territory. The simplest goal is to hold that figure steady over time with population growth, but this still allows for net positive growth in light emissions. A more ambitious goal is to gradually draw down light emissions by actively cutting waste. Given the extreme inefficiency of typical outdoor lighting installations, we believe there is significant, untapped potential to achieve meaningful emissions reductions through better design and operation of outdoor lighting, including making better use of lighting controls.

Like watershed systems, lightshed systems have multiple, conflicting uses that tend to spread both benefits and costs unevenly among users. To encourage cooperation leading to achievement of regional light emissions reductions goals, we envision something like a cap-and-trade system in which increasing light emissions in one part of the territory must be compensated for by reduced emissions in another. The right to emit light at night becomes a tradable commodity. Such a system could help offset the costs of lighting design and

retrofits required to reach emission reduction targets.

As an example, we consider the lightshed of southern Arizona, USA, centered on the Tucson metropolitan statistical area, which has a population of about 1 million inhabitants. A suggested boundary of this lightshed is shown in Figure 1. The boundary is drawn as the contour for which the zenith night-sky brightness is 50% higher than the presumed natural background level. Barentine *et al*. (2018) found that light emissions within the boundaries of the incorporated City of Tucson totaled 5.5×10^8 lumens, or about 1015 lumens per capita, in 2017. The population rate of change in the last decade averaged about +0.5% $year^{-1}$, while satellite-indicated light emissions rose about 16% since 2017. We estimate the light consumption in 2025 to be about 1165 lumens per capita, which represents an increase of at least 15% in eight years.

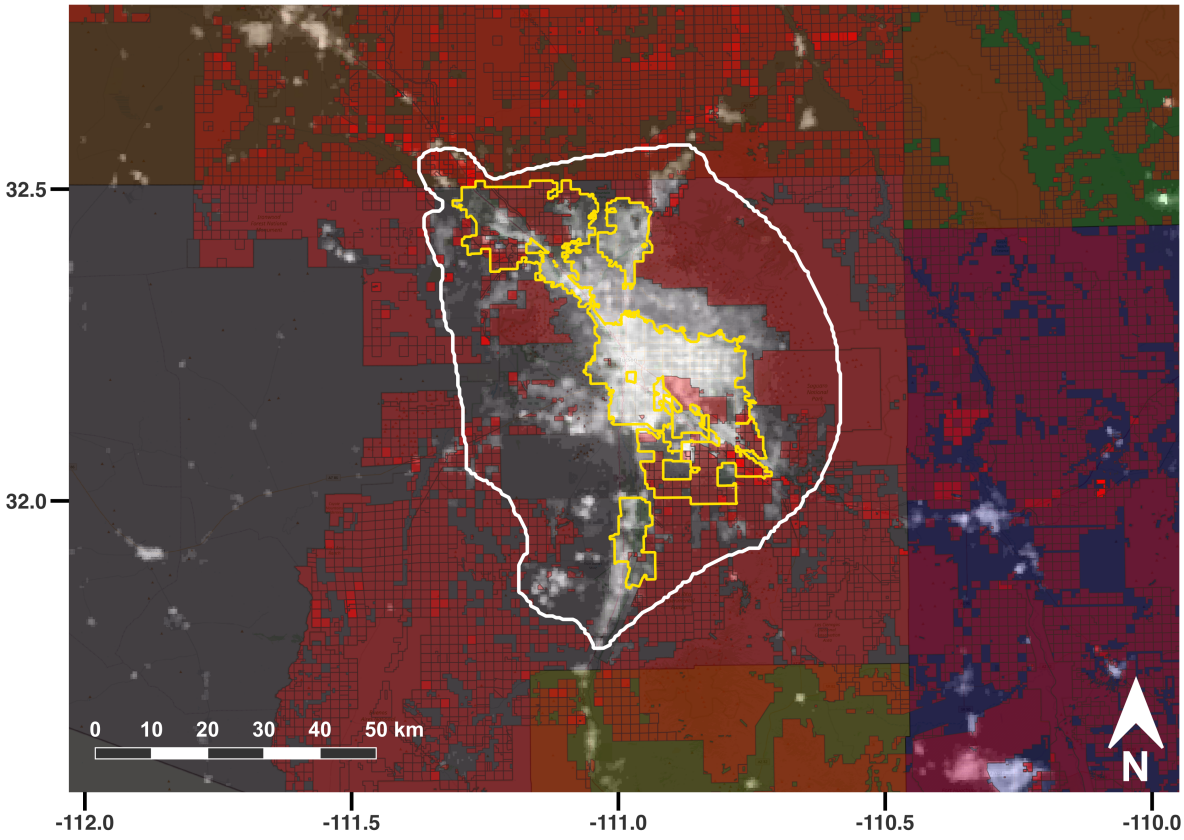

Fig. 1: A suggested lightshed boundary (white line) surrounding the greater Tucson, U.S., metropolitan area. Various colored, large polygons in the background represent county boundaries in the U.S. state of Arizona. Boundaries of incorporated municipalities are shown as yellow lines. Shaded red polygons represent lands owned by the State of Arizona or the U.S. federal government. The grayscale overlay is the VIIRS-DNB Nighttime Lights Monthly Cloud-Free Composite for February 2024. The base map is from OpenStreetMaps, licensed under the Open Database License.

References

Barentine JC, et al (2018) Skyglow changes over Tucson, Arizona, resulting from a municipal LED street lighting conversion. J of Quant Spectr and Rad Trans, 212, 10-23