Painting the parking lot red: an investigation of red LEDs' ability to mitigate light pollution's impacts on bat and insect habitat use

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Grant Category: Macro-ecology - Spatial distribution of animals and light

Background Information

The pervasive presence of artificial lighting on the global landscape has created a substantial problem for wildlife populations: light pollution. Two taxa that experience negative effects of artificial light are bats and nocturnal insects. Research has shown that some insects are drawn to short-wavelength light[1,2], effectively creating a vacuum effect that draws insects out of areas surrounding light fixtures and into open areas below the light[3]. Insects attracted to lights fly beneath them for extended periods of time throughout the night, often leading to mortality through sheer exhaustion or predation[3]. Bats can be broadly categorized as either light-opportunistic or light-averse, with light-opportunistic bats being attracted to lit areas, and light-averse bats avoiding lit areas[4,5]. While the scientific community has begun to explore the direct effects artificial light has on bats, the ecological consequences of these behavioral changes remain largely unknown. One experiment showed that red LEDs can be used to mitigate the effects many conventional lighting technologies have on bats and insects[6], but more research is necessary to assess the efficacy and universality of this mitigation technique.

Methods

During the summer of 2019 in Grand Teton National Park's Colter Bay Village, we will be monitoring bat and insect habitat use at a fine spatial scale while manipulating lightscape characteristics in order to better understand the relationship between bats, insects, and artificial light. Our monitoring sites are distributed within, and immediately surrounding, a large T-shaped parking lot in the village that is illuminated by 32 street lights (Figure 1). We will install proprietary LED luminaires that allow users to choose whether red or white light is emitted from the luminaires, and also control their brightness. We will change the color of light illuminating the parking lot between red and white, and pseudorandomly change the brightness of the luminaires, in three day blocks throughout the summer to ensure that temporal variation in bat and insect activity is controlled for between lighting treatments.

The parking lot will be split into three monitoring areas, with an additional five monitoring areas in unlit habitat surrounding the parking lot serving as "dark controls". In each of these monitoring areas, we will record bat activity using radiotelemetry and passive acoustic monitors. In June and July, we will capture bats in the areas surrounding our monitoring sites and fit them with radiotags that emit a radio signal every five seconds. Radiotelemetry dataloggers, each paired with a Yagi five-element antenna, will be placed in all monitoring areas to record radiotag fixes within their detection radius. We will also deploy Wildlife Acoustics SM4BATs in

each monitoring area to record bat echolocation calls. To record nightly insect abundance within each monitoring site, we will also deploy flight intercept traps[7].

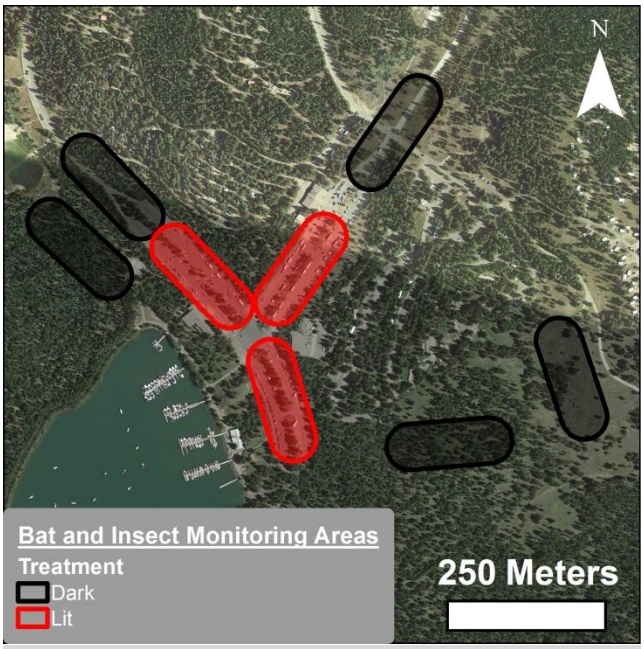

Figure 1. Bat and insect monitoring areas in Colter Bay Village, Grand Teton National Park, WY.

Predictions

We predict that when our artificially lit monitoring sites are illuminated by red light, light-averse bats will increase their activity, light-opportunistic bats will decrease their activity, and insects will decrease in abundance in comparison to periods of white light illumination.

Anticipated Analyses

Proceeding data collection, we will use SonoBat 4.3.0 to determine the number of calls attributed to a given species for each site-night. We will also count the number of insects collected by flight intercept traps for each site-night, and record the total mass of each site-night's sample. Additionally, for each radiotagged bat we will calculate the duration of each foraging bout within a monitoring area. Using these data, we will create three mixed effects models for each bat species and one model for insects to determine how lightscape characteristics influence: 1) bat calling effort; 2) the total amount of time bats spend in artificially lit areas; 3) the duration of bat foraging bouts in artificially lit areas; and 4) insect habitat use in artificially lit areas. The results of this research will provide valuable information for the conservation of bats and insects in artificially lit habitats.

Ethical Statement of Animal Research

The IACUC protocol for this project is still in review, however all committee concerns have been addressed, and the protocol is expected to be approved on May 20, 2019. Proof of protocol approval will be sent to the Zoological Lighting Institute as soon as possible.

References

1. van Langevelde, F., Ettema, J. A., Donners, M., WallisDeVries, M. F. & Groenendijk, D. Effect of spectral composition of artificial light on the attraction of moths. *Biol*. *Conserv*. **144**, 2274–2281 (2011).
2. Macgregor, C. J., Pocock, M. J. O., Fox, R. & Evans, D. M. Pollination by nocturnal Lepidoptera, and the effects of light pollution: a review. *Ecol*. *Entomol*. **40**, 187–198 (2015).
3. Eisenbeis, G. Artificial Night Lighting and Insects: Attraction of Insects to Streetlamps in a Rural Setting in Germany. in *Ecological Consequences of Artificial Night Lighting* (eds. Rich, C. & Longcore, T.) 281–304 (Island Press, 2006).
4. Rowse, E. G., Lewanzik, D., Stone, E. L., Harris, S. & Jones, G. Dark Matters: The Effects of Artificial Lighting on Bats. in *Bats in the Anthropocene: Conservation of Bats in a Changing World* (eds. Voigt, C. C. & Kingston, T.) 187–213 (Springer International Publishing, 2016). doi:10.1007/978-3-319-25220-9_7
5. Rowse, E. G., Harris, S. & Jones, G. Effects of dimming light-emitting diode street lights on light-opportunistic and light-averse bats in suburban habitats. *R*. *Soc*. *Open Sci*. **5**, 180205 (2018).
6. Spoelstra, K. *et al*. Response of bats to light with different spectra: light-shy and agile bat presence is affected by white and green, but not red light. *Proc R Soc B* **284**, 20170075 (2017).
7. Wakefield, A. *et al*. Quantifying the attractiveness of broad-spectrum street lights to aerial nocturnal insects. *J*. *Appl*. *Ecol*. **55**, 714–722 (2018).

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Biology M.S. student at Boise State University with research interests in sensory ecology and wildlife conservation. Possessing an unrelenting work ethic and a desire to learn. Driven by a passion for wildlife and the outdoors.

EDUCATION

BOISE STATE UNIVERSITY **Boise, ID**
M.S. Biology Student August *2018 - Present*

- **Academic Advisor:** Jesse R. Barber, Ph.D.
- **Current GPA:** 4.00
- **Representative Coursework:** Landscape Ecology, Principles and Processes in Ecology, Evolution and Behavior, and Biometry

MIDDLEBURY COLLEGE **Middlebury, VT**
B.A. Conservation Biology *February 2015 - May 2018*

- **Cumulative GPA:** 3.74
- **Representative Coursework:** Ecology and Evolution, Vertebrate Natural History, Introduction to GIS, Animal Behavior, Biostatistics, Conservation Genetics, and Aquatic Ecology

RESEARCH EXPERIENCE

BOISE STATE UNIVERSITY **Pioneer Mountains, ID**
Sensory Ecology Technician *May 2018 - August 2018*

- Deployed and maintained sound playback systems, passive acoustic monitoring equipment, insect trapping equipment, and camera traps.
- Conducted targeted mist netting for passerines and assisted in sample collection.
- Deployed camera traps, giving-up density trays, and tracking tubes to monitor small mammals.
- Hauled pack loads of up to 135 pounds over 3 kilometers to study sites.
- Assisted project coordinators in logistics management.
- Operated all-terrain vehicles and four-wheel drive trucks to access remote study sites.
- Performed computer data entry and quality assurance/quality control

BOISE STATE UNIVERSITY **Pioneer Mountains, ID**
Sensory Ecology Technician *June 2017 - August 2017*

- Deployed and maintained sound playback systems, passive acoustic monitoring equipment, insect trapping equipment, and camera traps.
- Hauled pack loads of up to 135 pounds over 3 kilometers to study sites.
- Conducted 123 avian point counts in montane riparian ecosystems.

- Assisted project coordinators in logistics management.
- Operated all-terrain vehicles and four-wheel drive trucks to access remote study sites.
- Performed computer data entry and quality assurance/quality control

MIDDLEBURY COLLEGE **Middlebury, VT**
Vertebrate Natural History Teaching Assistant *September 2016 - November 2016*

- Guided students in assembling and disassembling mist nets, as well as handling birds captured in the nets.
- Banded and recorded morphometric measurements of captured birds.
- Taught students to identify, age, sex, and band birds that had been captured.
- Ensured data regarding birds banded was accurately documented.

NATIONAL PARK SERVICE **Grand Teton National Park, WY**
Ecology of Bats Intern *June 2016 - September 2016*

- Collected data on bat populations using remote and handheld ultrasonic recording devices during both daytime and nighttime hours without supervision.
- Collected data on 428 human-made structures and 326 light fixtures around the park with both pictures and written descriptions during both daytime and nighttime hours without supervision.
- Identified 26 suitable locations for recording devices to be placed for bat population data collection, as well as representative lightscapes and structures for light and human activity level data collection.
- Created forms that allowed for the consistent collection of data and metadata.
- Independently communicated with parties around the park to arrange times for data collection.
- Performed computer data entry and quality assurance/quality control

MIDDLEBURY COLLEGE **Middlebury, VT**
Vertebrate Natural History Student *September 2015 - November 2015*

- Mist netted and banded passerines.
- Conducted electrofishing surveys.
- Live-trapped small mammals.

TEACHING EXPERIENCE

BOISE STATE UNIVERSITY **Boise, ID**
Human Anatomy and Physiology Lab Instructor *August 2018 - Present*

- Prepare and give lectures on subjects within the field of human anatomy and physiology.
- Create and proctor exams.

MIDDLEBURY COLLEGE **Middlebury, VT**
Introduction to GIS Teaching Assistant *February 2017 - May 2017*

- Assisted students in mastering basic GIS workflows.
- Provided cartographic advice to students.