European Regional Development Fund
Investing in your Future

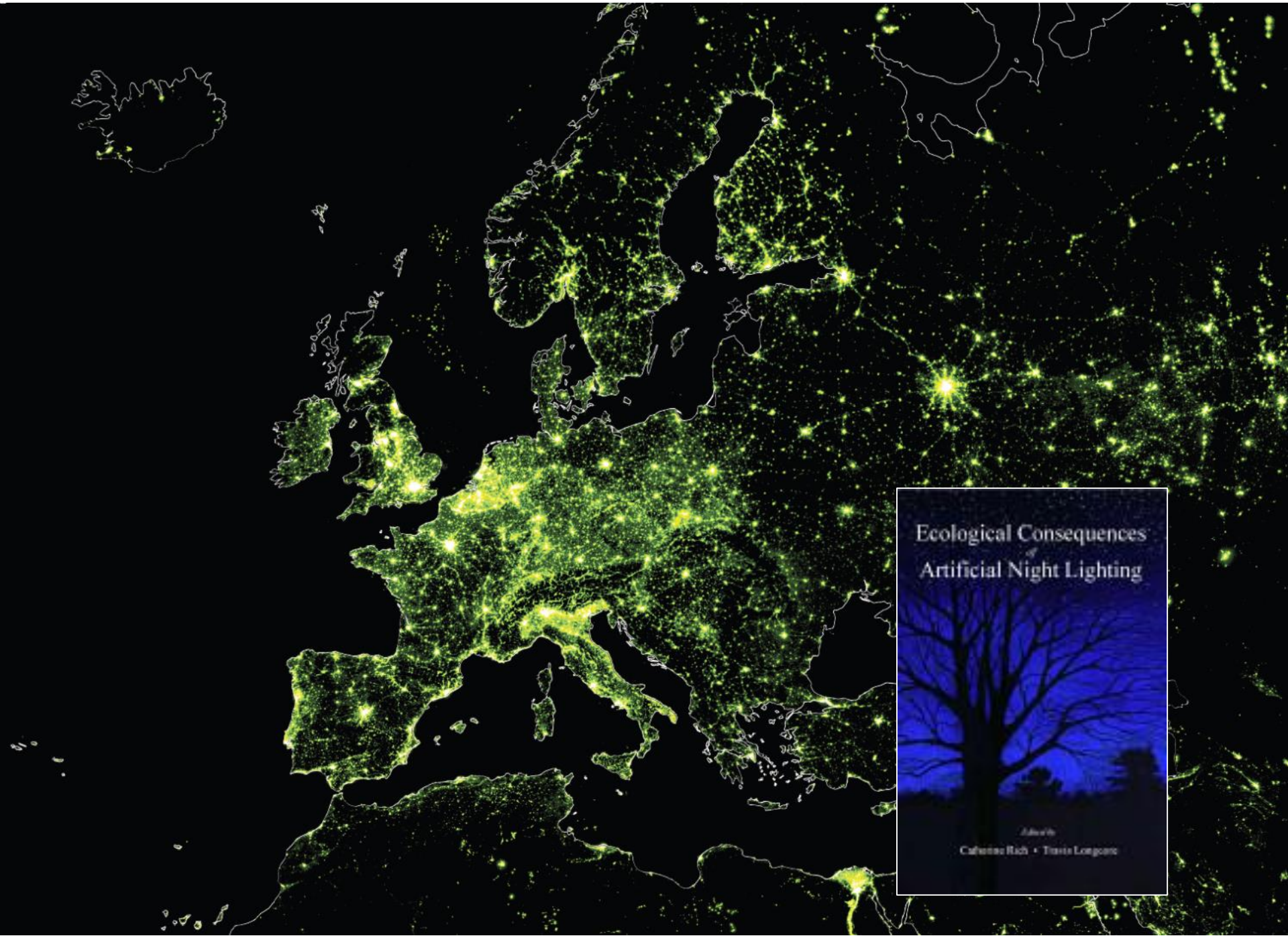
convergence
for economic transformation

University of Exeter

Environment and Sustainability Institute

Measuring biological light pollution and uncovering its ecological effects

Jon Bennie, Exeter University, Penryn Campus


Ecological Consequences
of
Artificial Night Lighting
Catherine Rich • Travis Longcore

Plant seasonal timing (phytochrome)

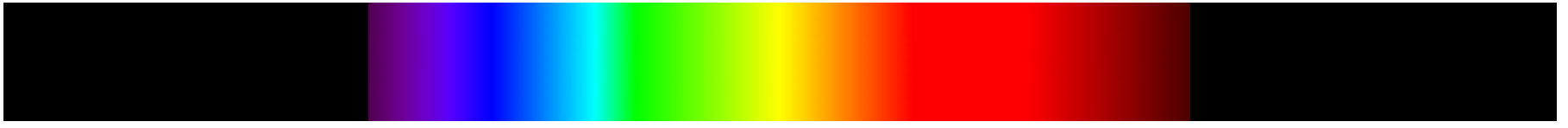
on off

Plant growth

Daily cycle in mammals and birds
(melatonin suppression)

Bumblebee vision

Human vision

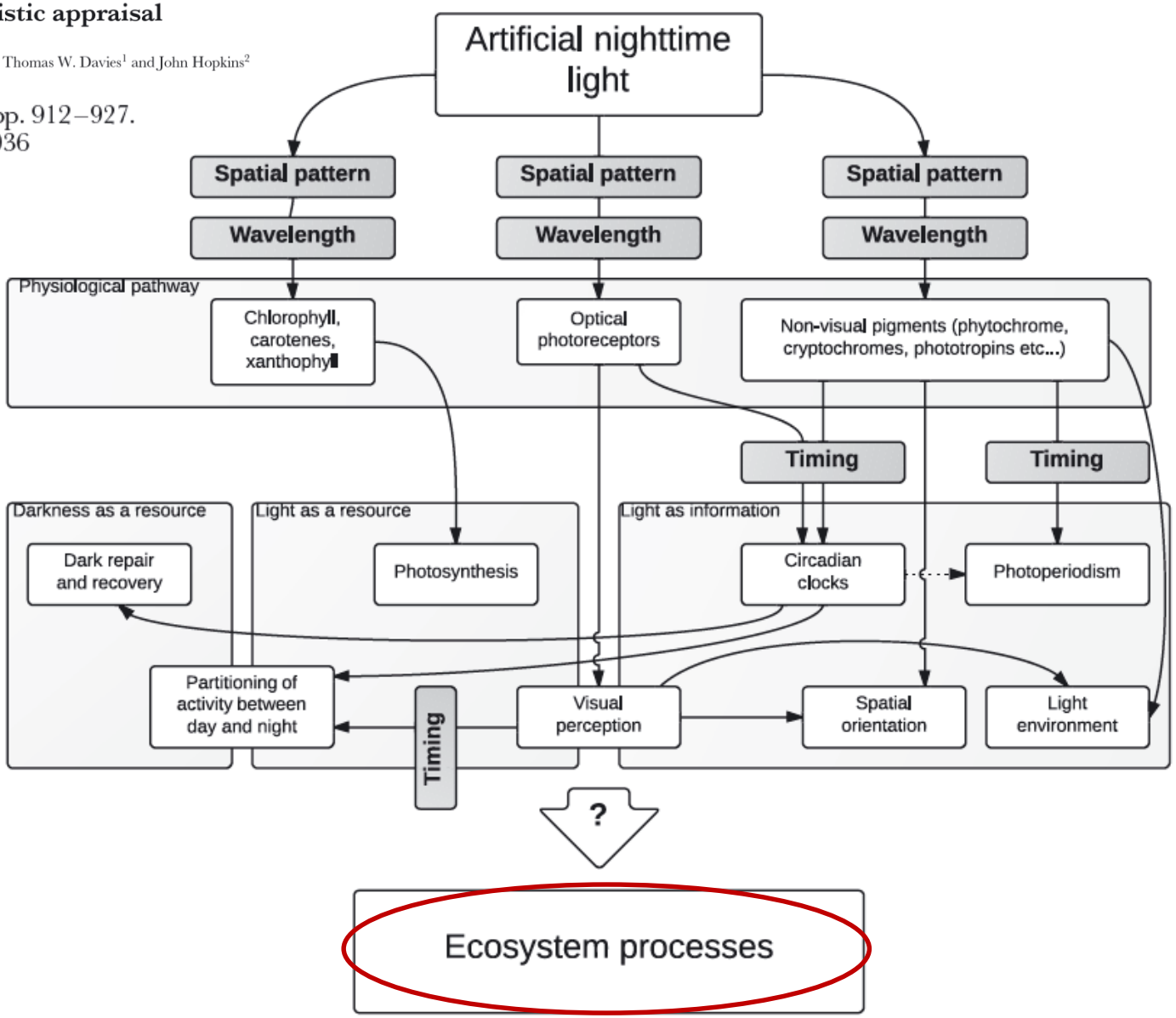


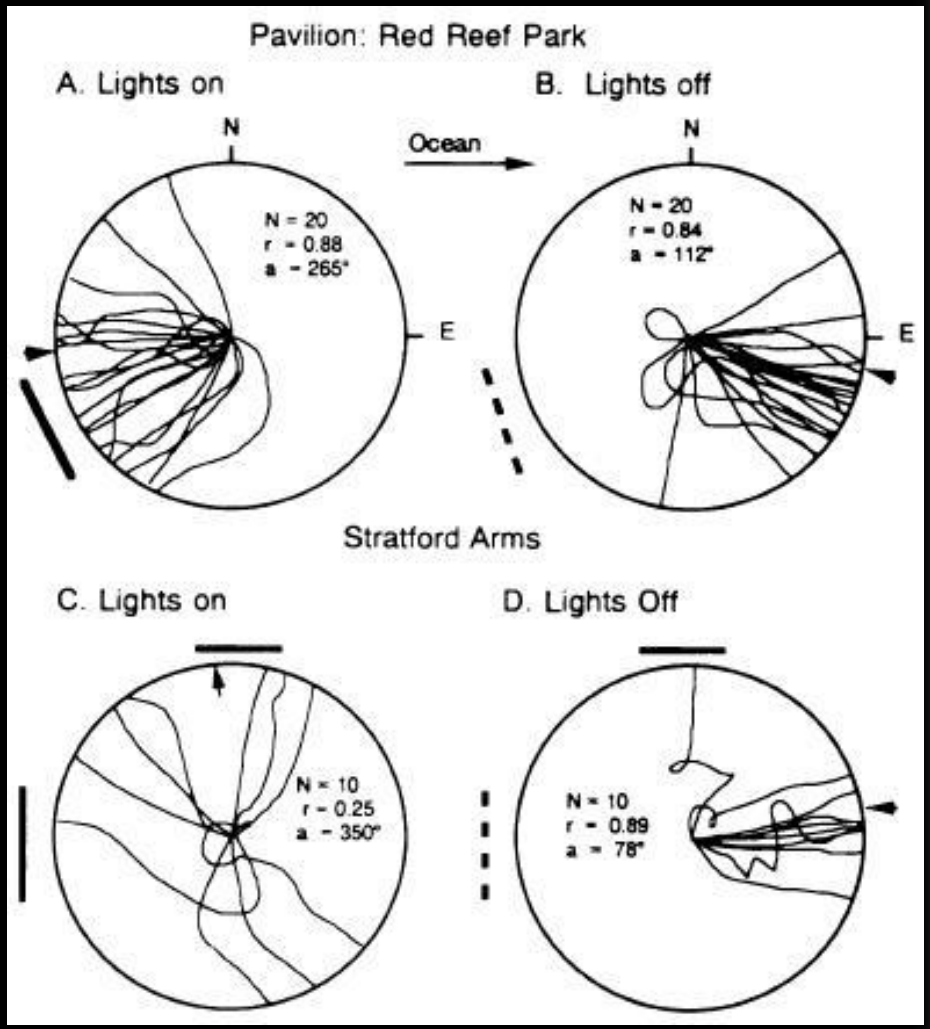
Ultra-violet Visible light Far-red

The ecological impacts of nighttime light pollution: a mechanistic appraisal

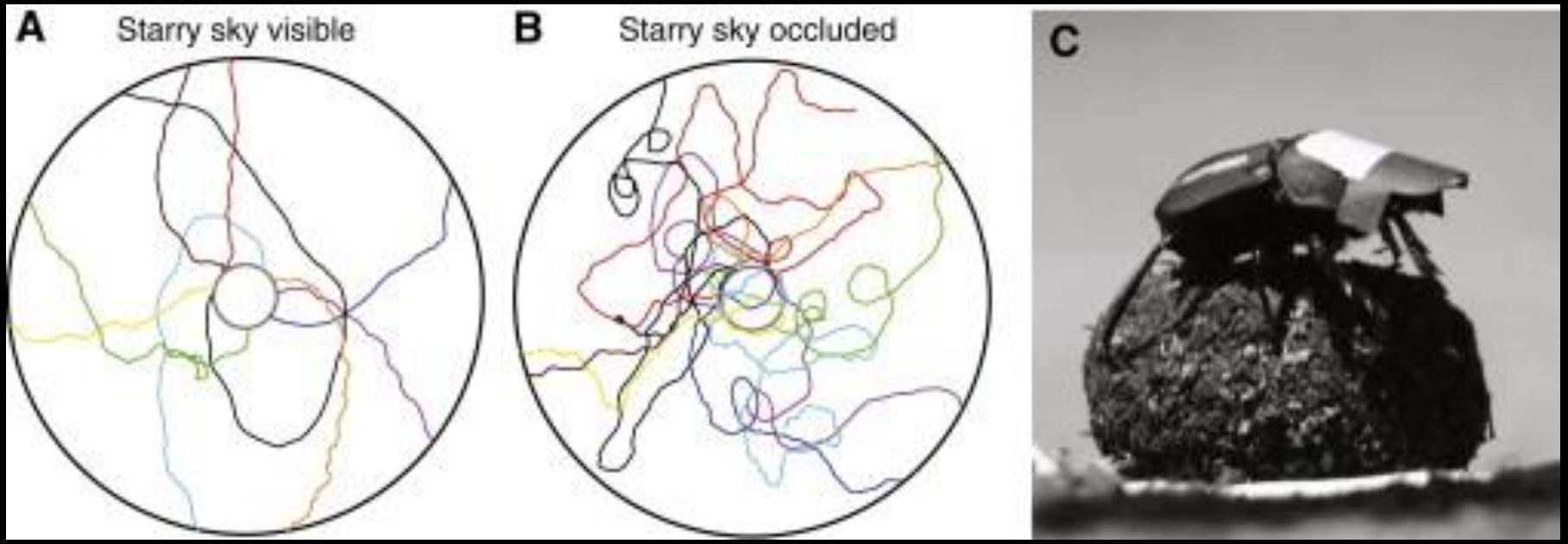
Kevin J. Gaston[1,*], Jonathan Bennie[1], Thomas W. Davies[1] and John Hopkins[2]

Biol. Rev. (2013), **88**, pp. 912–927.
doi: 10.1111/brv.12036





Behavior of Loggerhead Sea Turtles on an Urban Beach. II. Hatchling Orientation
Salmon et al.
Vol. 29, No. 4 (Dec., 1995), pp. 568-576



Dacke et al., (2013) Dung beetles use the milky way for orientation
Current Biology 23 (4) 298-300

Small ermine moths (*Yponomeuta cagnagella*) adapt to urban areas by reducing their "flight to light" behaviour

Altermatt & Ebert Reduced flight-to-light behaviour of moth populations exposed to long-term urban light pollution
Biology Letters (2016), doi: 10.1098/rsbl.2016.0111

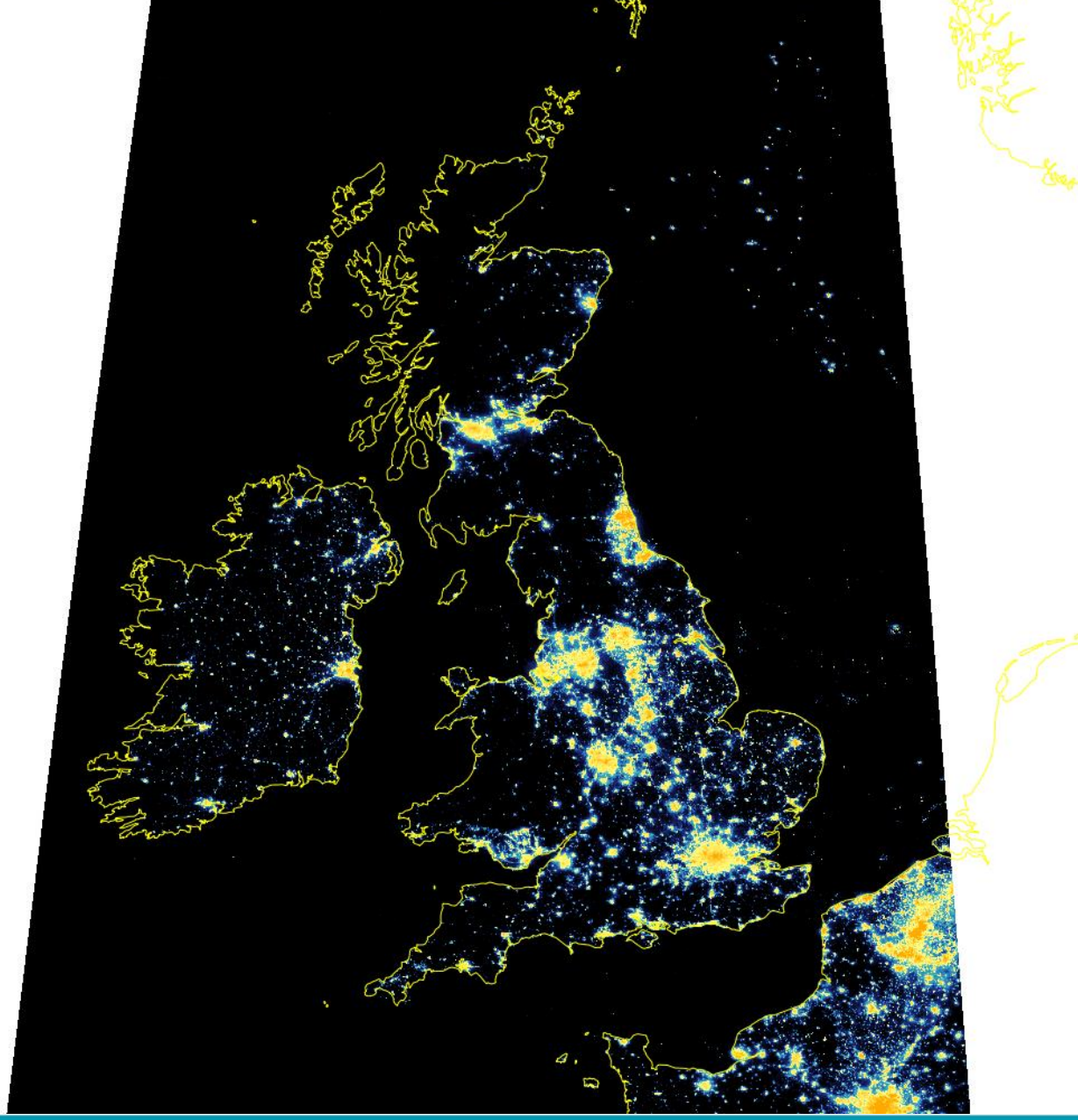
Ecological effects or artificial light

- Artificial light can have profound effects on the **physiology** and **behaviour** of species
- Mediated through the effects on **rhythms**, **spectra** and **intensity** of natural light
- How does this affect **populations** and structure of ecological **communities**?
- How **widespread** are these effects in ecosystems?

Search for evidence for:

- Species **population-**level effects of artificial light?
- Species **community-**level effects of artificial light?
- **Regional effects** of artificial light (sky-glow)?
- **Landscape effects** of networks of artificial light?
- Opportunities to minimise ecological effects.

-> **ECOLIGHT project**

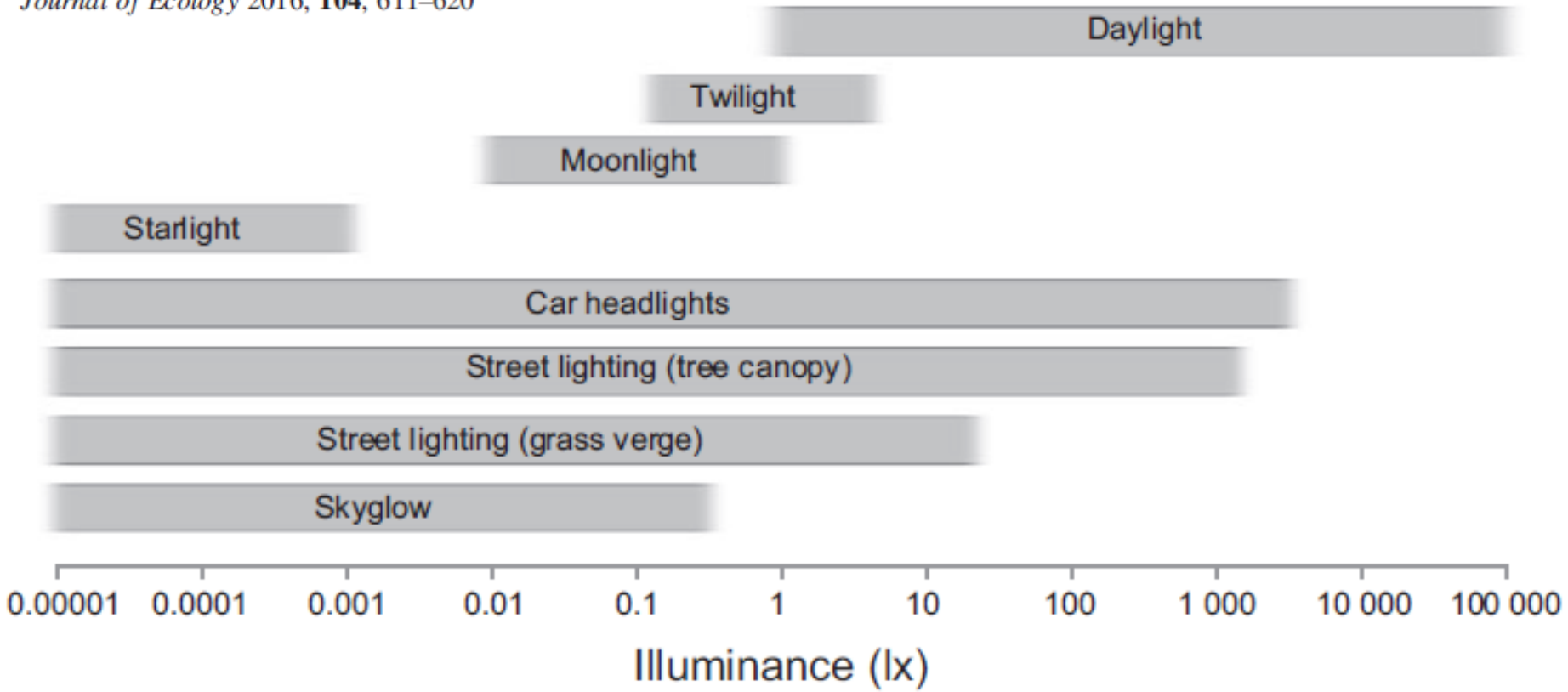



OR
OFFICE
USE

Ecological effects of artificial light at night on wild plants

Jonathan Bennie*, Thomas W. Davies, David Cruse and Kevin J. Gaston

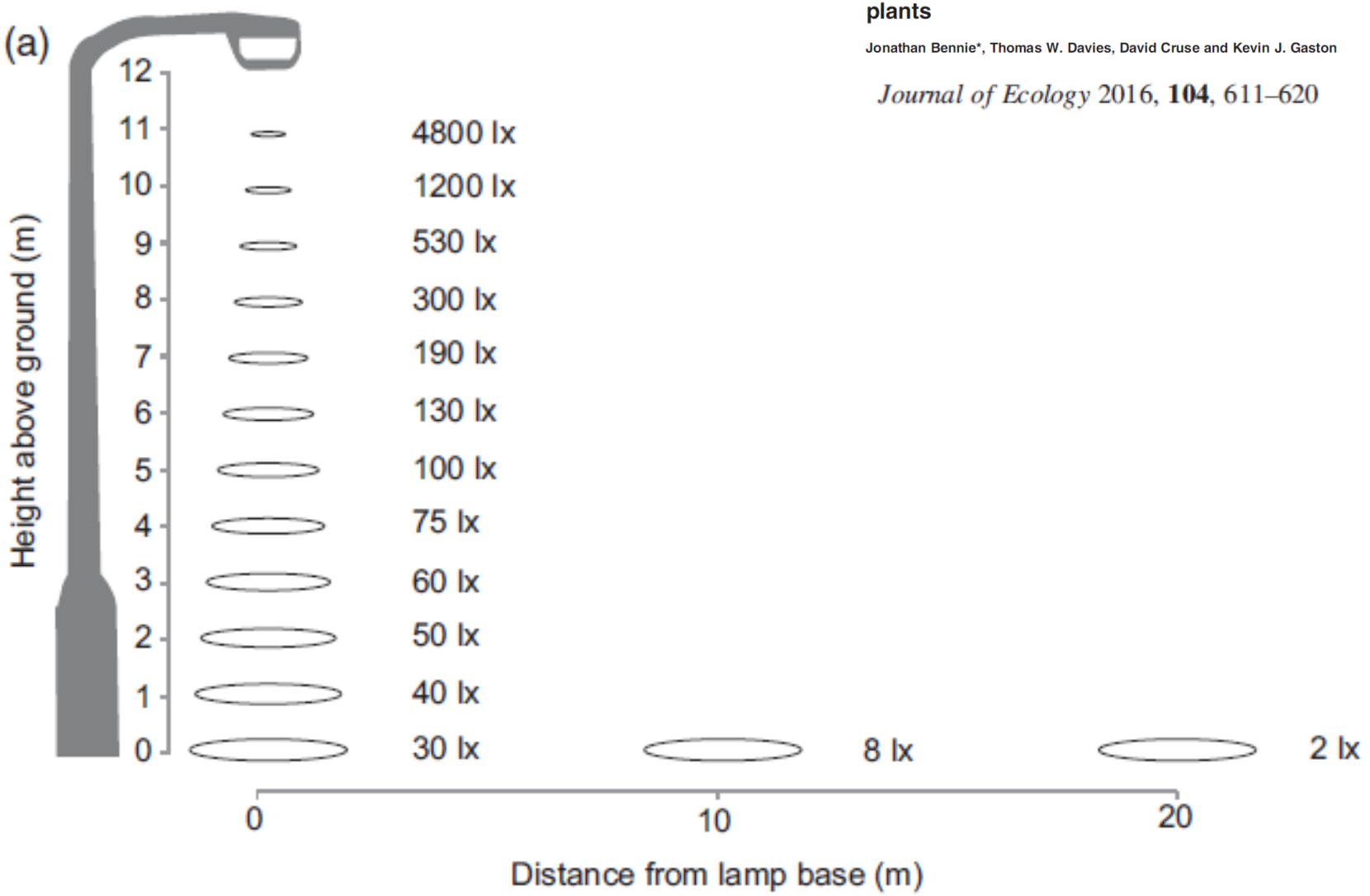
Journal of Ecology 2016, **104**, 611–620



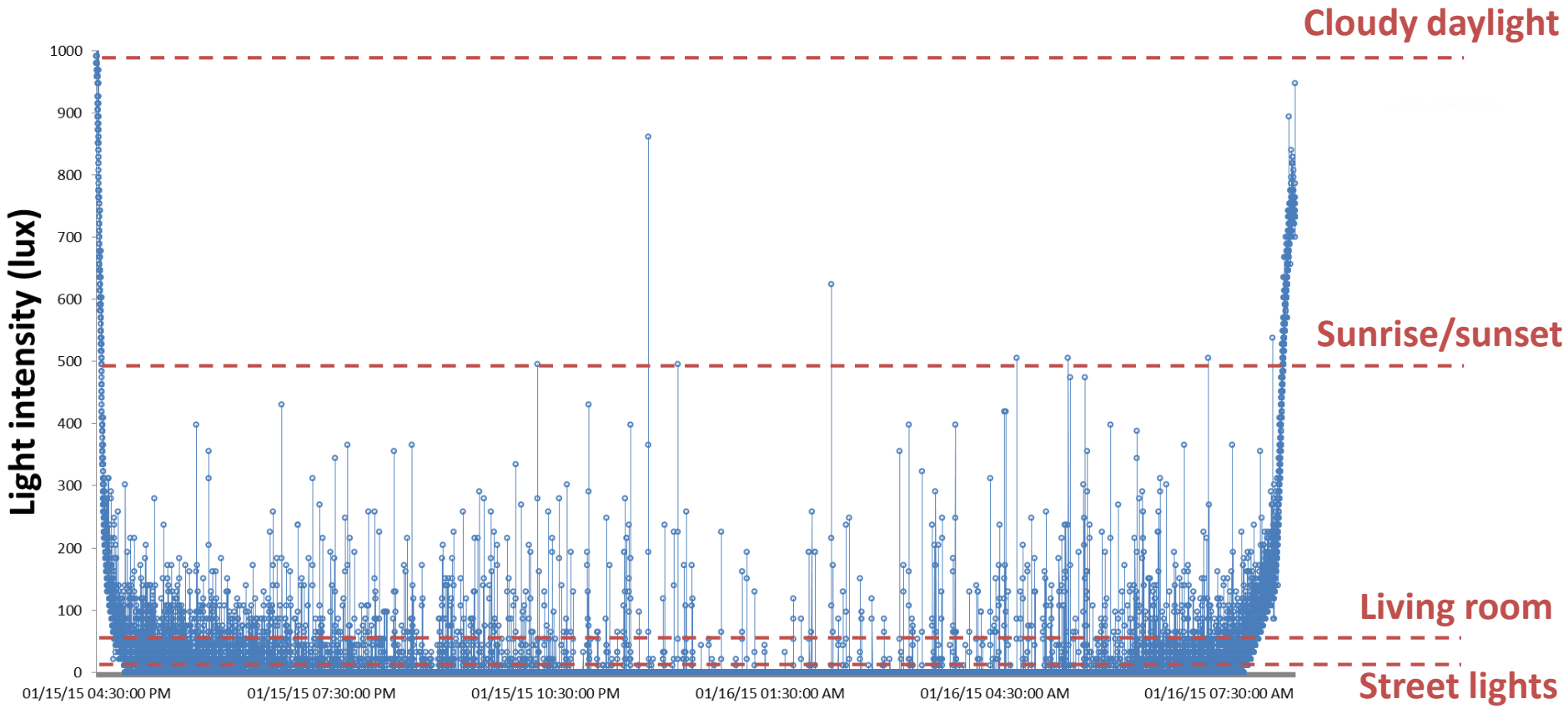
Ecological effects of artificial light at night on wild plants

Jonathan Bennie*, Thomas W. Davies, David Cruse and Kevin J. Gaston

Journal of Ecology 2016, **104**, 611–620



Light measured in hedgerow beside roadway from sunset to sunrise

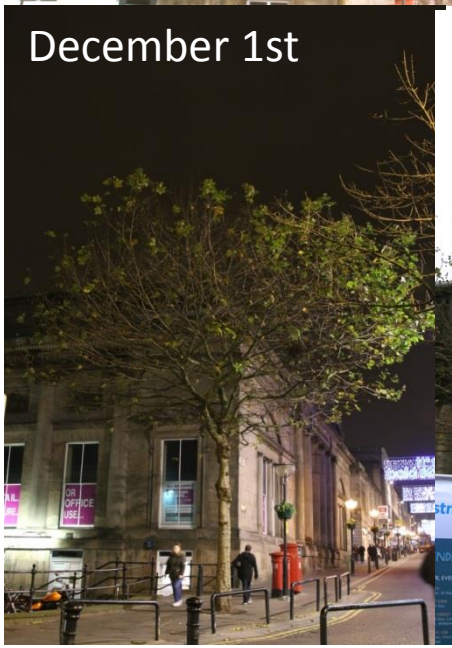


THE EFFECT OF STREET LIGHTS IN DELAYING LEAF-FALL IN CERTAIN TREES [1]

Edwin B. Matzke

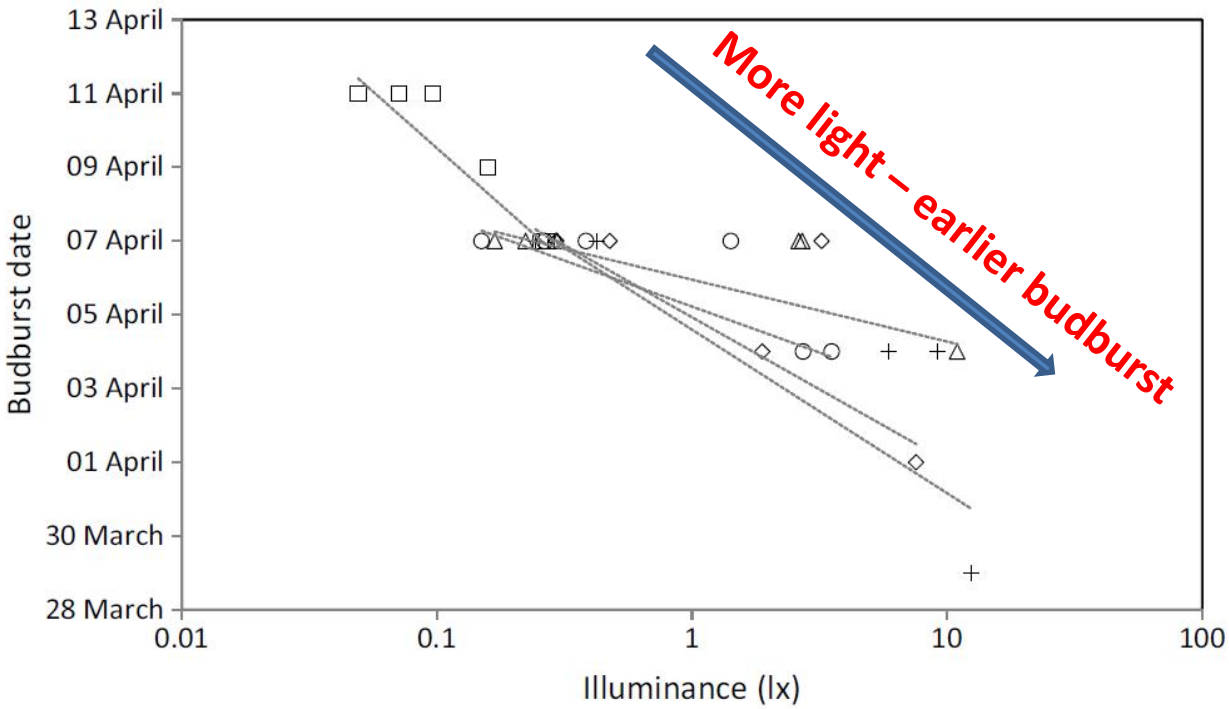
American Journal of Botany, Vol. 23, No. 6 (Jun., 1936), pp. 446-452


November 17th


December 1st


December 6th

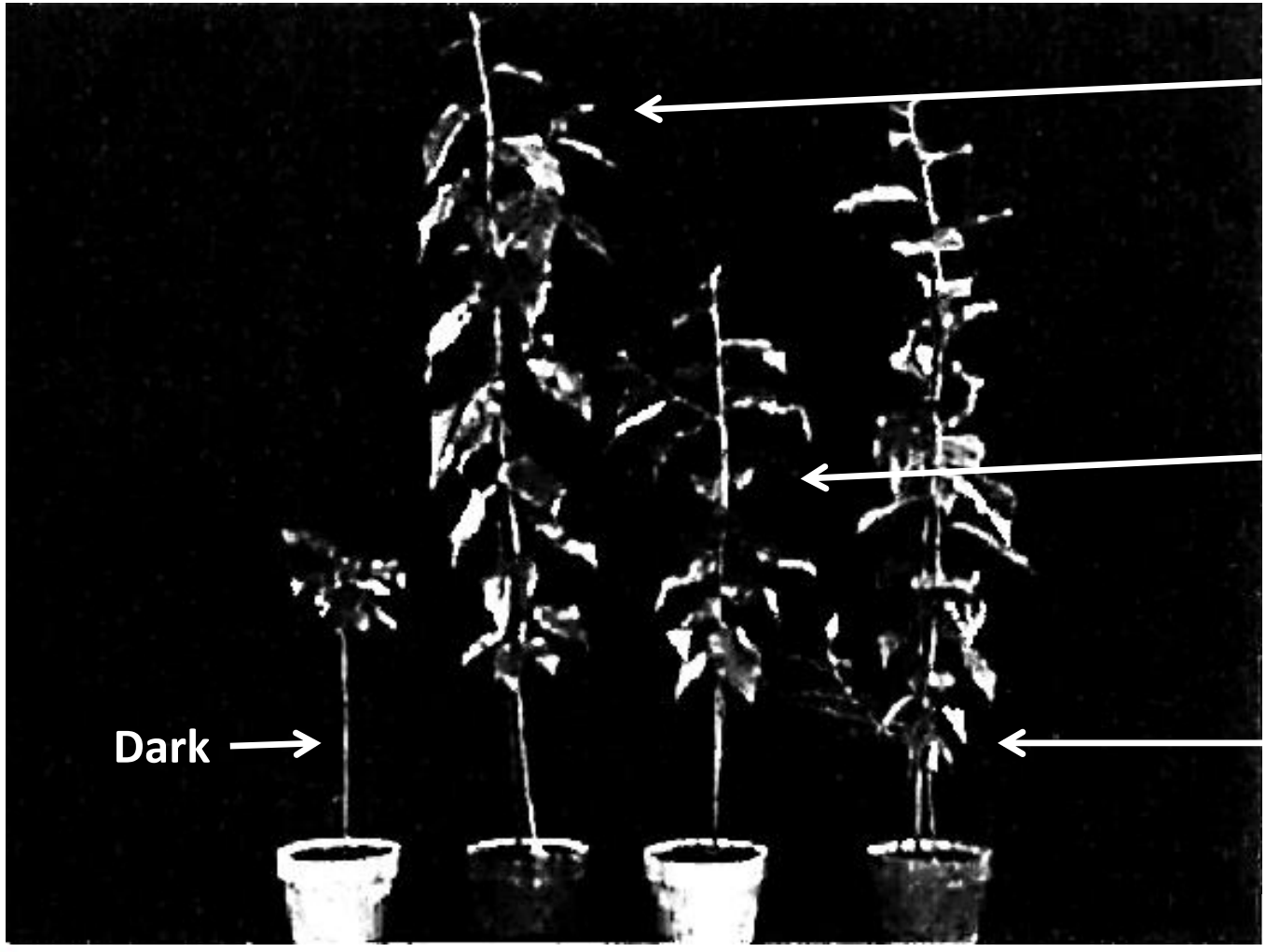

30th March

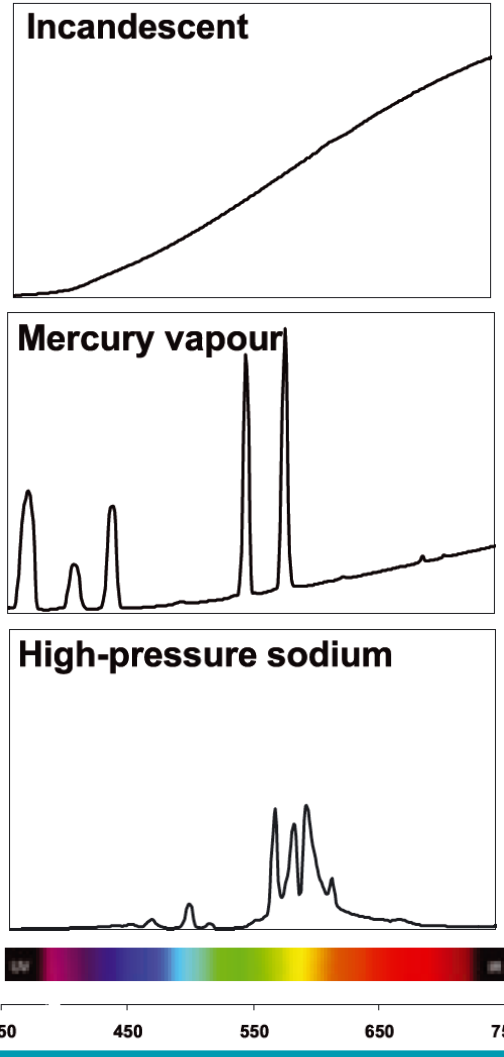


Empirical measurement of the time of budburst on trees near path lighting on Exeter University campus

Effectiveness of Five Vision-Lighting Sources on Photo-Regulation of 22 Species of Ornamental Plants[1]

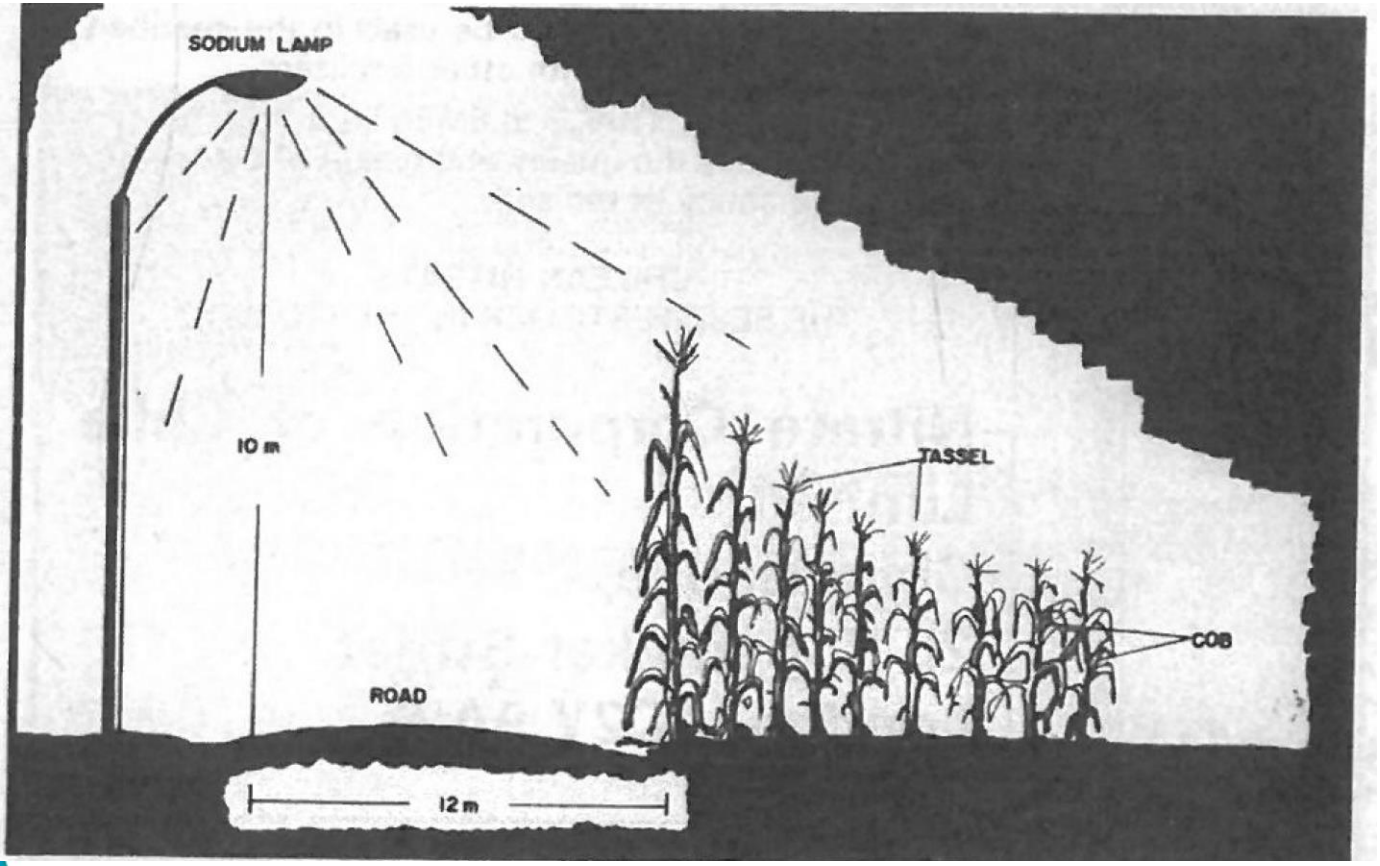
Henry M. Cathey and Lowell E. Campbell[2, 3]
Agricultural Research Service U.S. Department of Agriculture, Beltsville Agricultural Research Center, Beltsville, MD

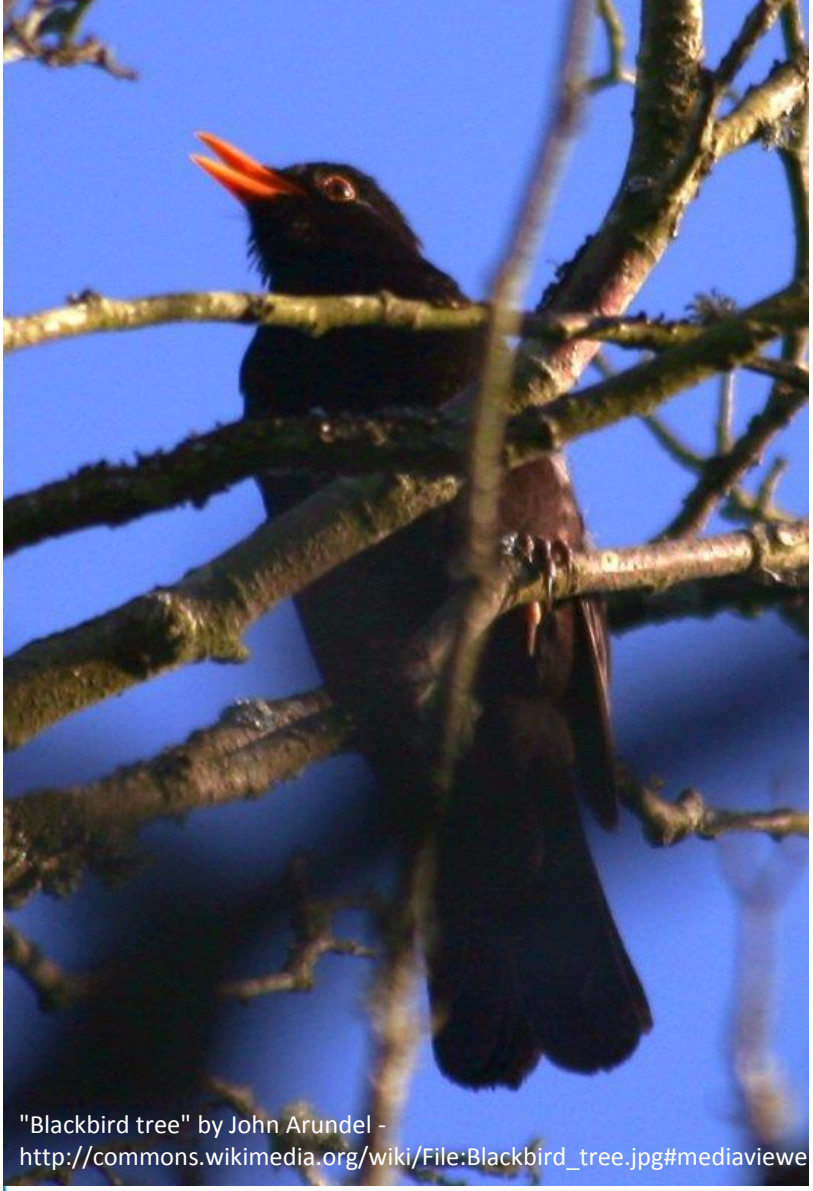




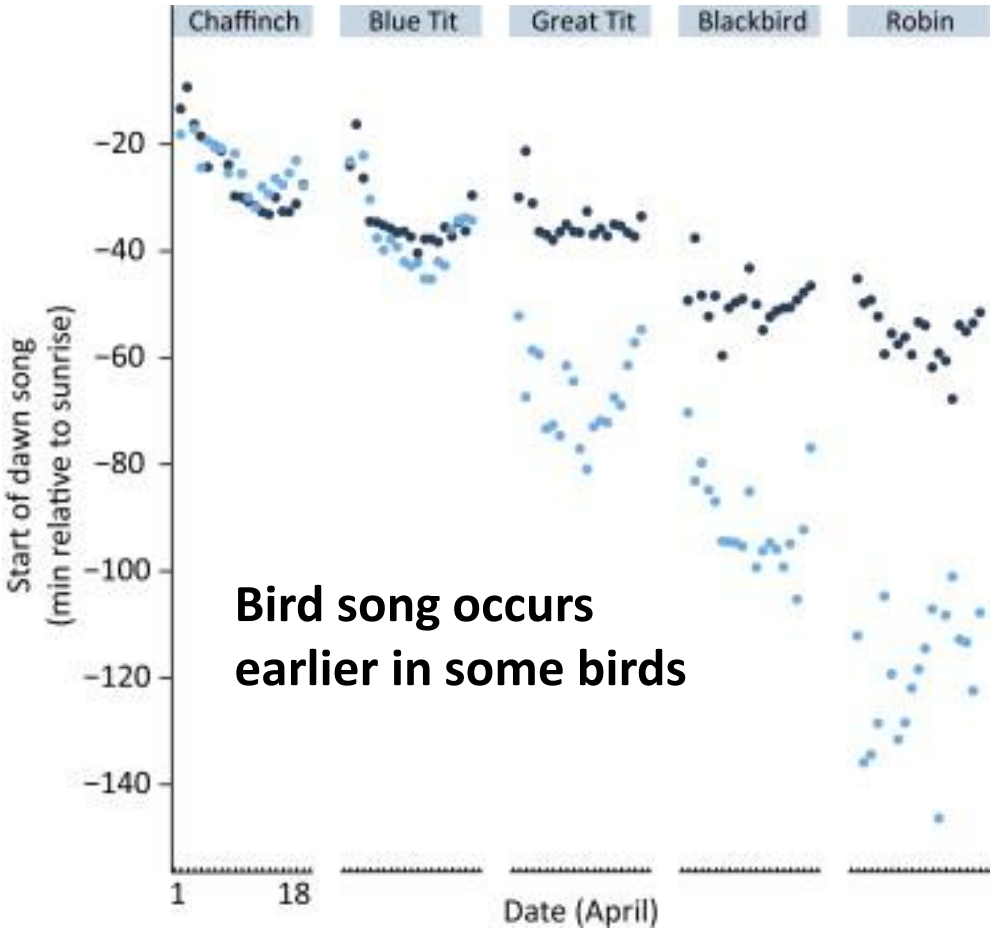
High pressure sodium street lights affect crops in Ghana

World Crops, November/December 1981





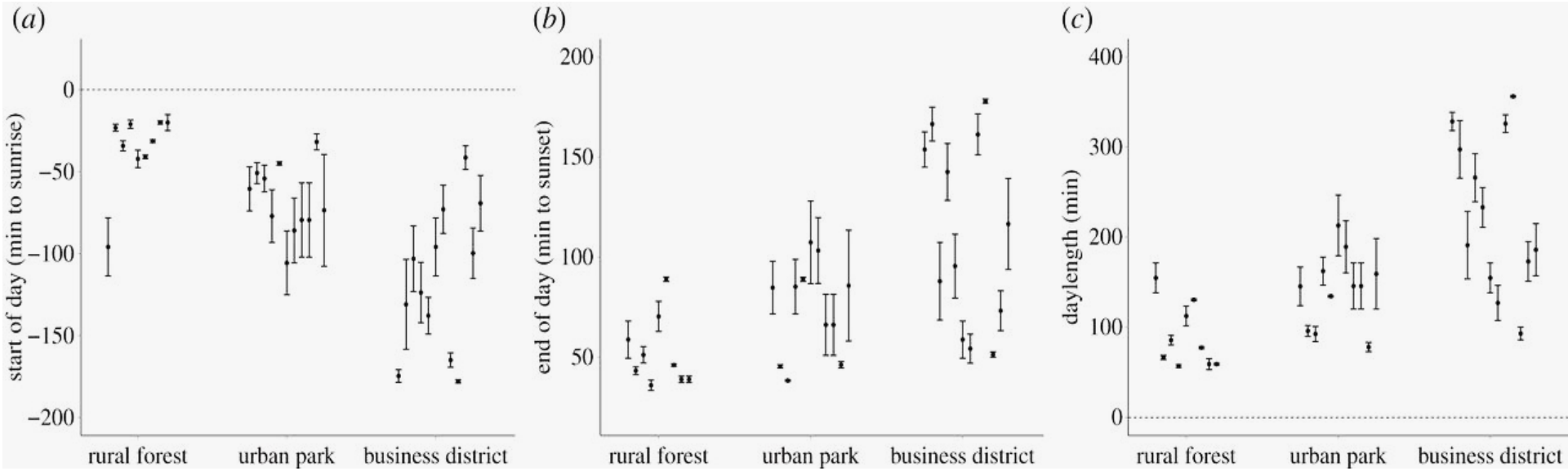
"Blackbird tree" by John Arundel - http://commons.wikimedia.org/wiki/File:Blackbird_tree.jpg#mediaviewe



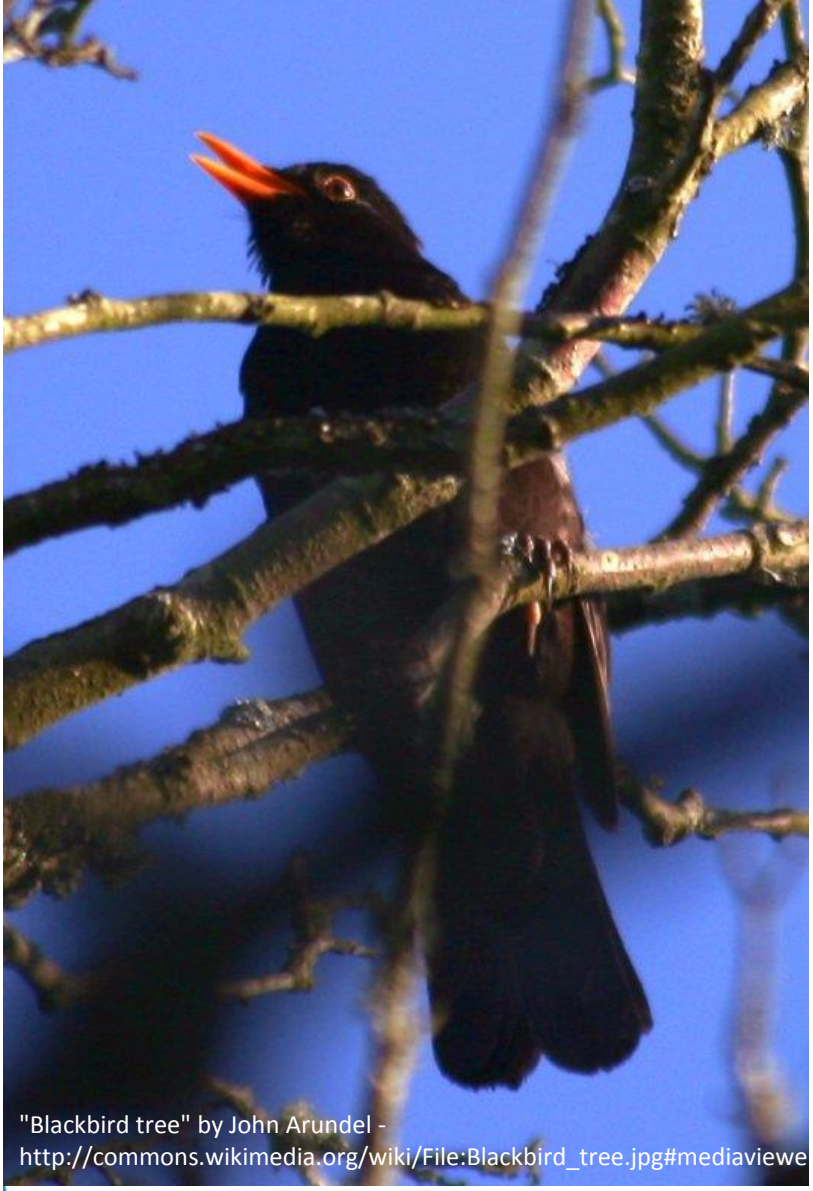
Bird song occurs earlier in some birds

Artificial Night Lighting Affects Dawn Song, Extra-Pair Siring Success, and Lay Date in Songbirds

Current Biology *20*, 1735–1739, October 12, 2010 DOI 10.1016/j.cub.2010.08.028



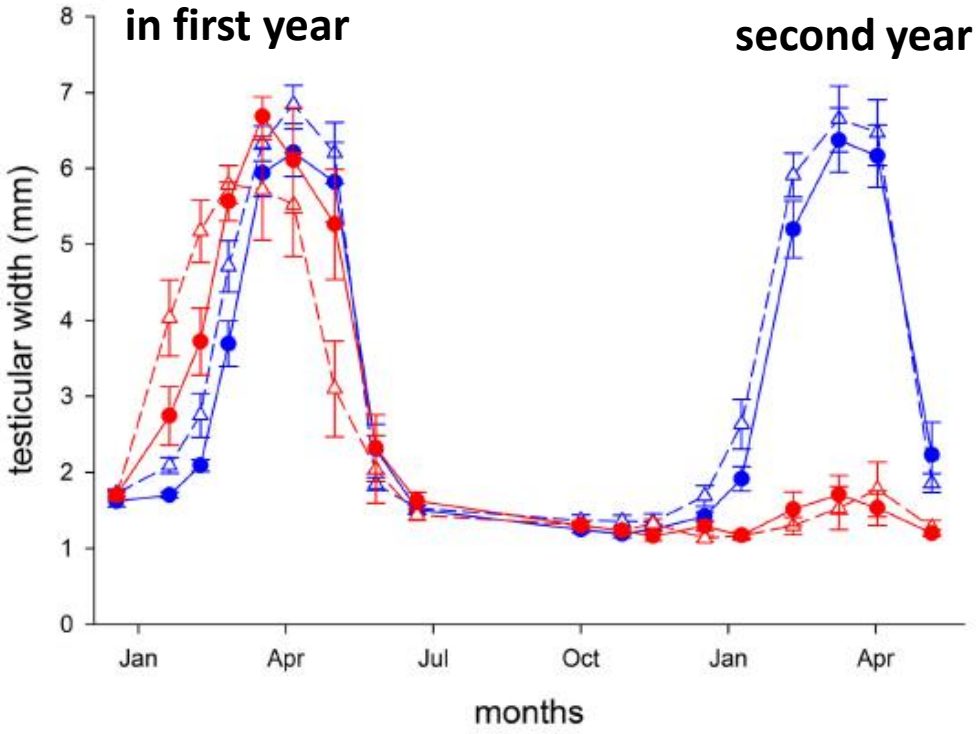
Does light pollution alter daylength? A test using light loggers on free-ranging European blackbirds (*Turdus merula*)
Dominoni & Partecke **2015** Phil Trans B **Volume: 370 Issue: 1667**



"Blackbird tree" by John Arundel - http://commons.wikimedia.org/wiki/File:Blackbird_tree.jpg#mediaviewe

Blackbirds exposed to streetlight mature earlier in first year

Blackbirds exposed to streetlight do not mature in second year



Long-Term Effects of Chronic Light Pollution on Seasonal Functions of European Blackbirds (*Turdus merula*)

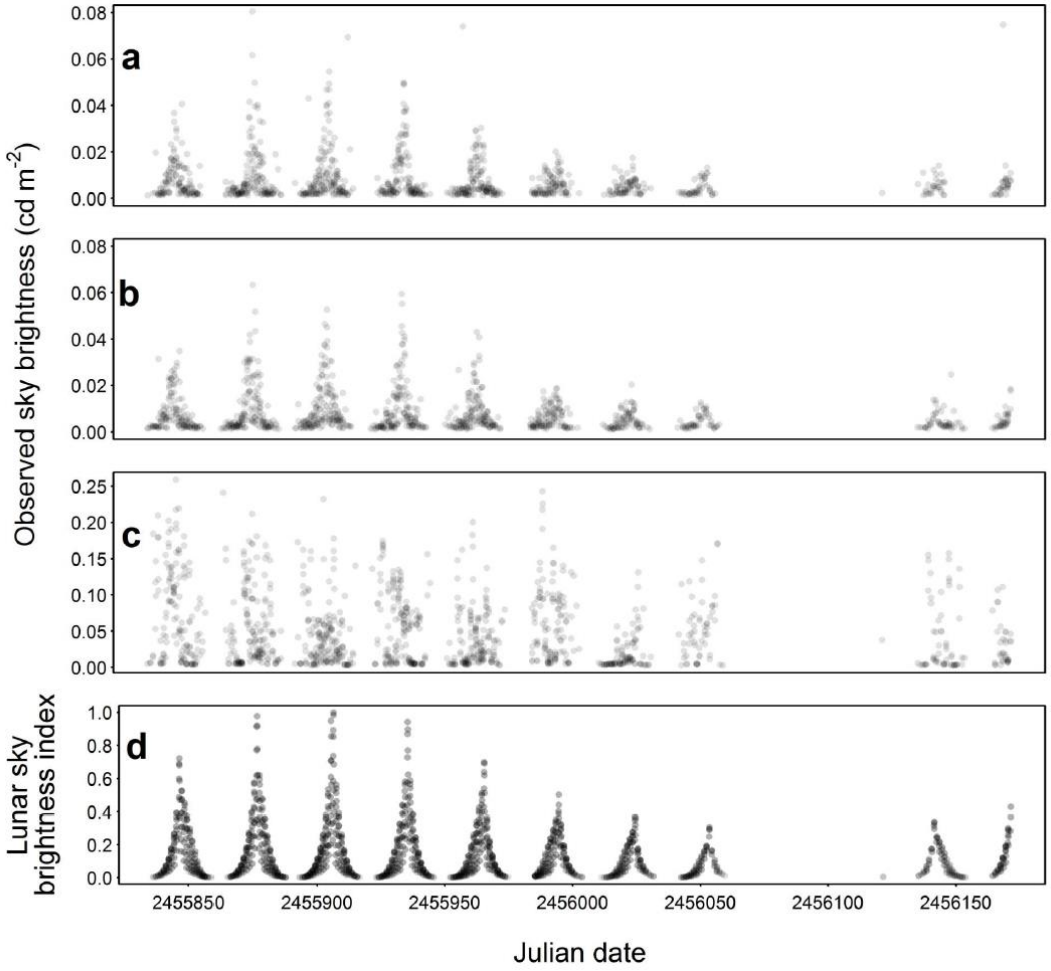
Davide M. Dominoni[1,2,3*], Michael Quetting[1], Jesko Partecke[1,2]

PLOS ONE | www.plosone.org December 2013 | Volume 8 | Issue 12 | e85069

Artificial light alters natural regimes of night-time sky brightness

Thomas W. Davies, Jonathan Bennie, Richard Inger & Kevin J. Gaston

SCIENTIFIC REPORTS | 3 : 1722 | DOI: 10.1038/srep01722



20 km from city

9 km from city

City Centre

Natural lunar cycle

Barn owl sensitive to light

"Barn Owl flying" by Kristina Servant - https://www.flickr.com/photos/xkristinax/9649002129/. Licensed under CC BY 2.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Barn_Owl_flying.jpg#mediaviewer/File:Barn_Owl_flying.jpg

illumination to a nocturnally foraging shorebird

Ross G. Dwyer[1]*, Stuart Bearhop[1], Hamish A. Campbell[2] and David M. Bryant[1]

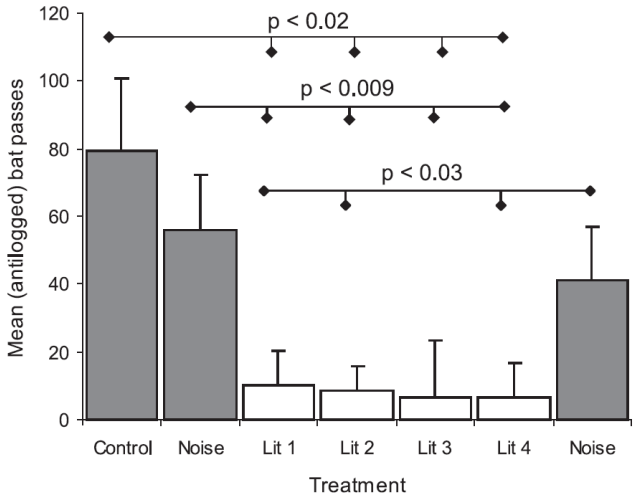
Journal of Animal Ecology 2013, **82**, 478–485

Redshank have two modes of feeding. Birds attracted to oil refinery use daytime mode (eyesight) which is more efficient than nocturnal mode of feeding by probing

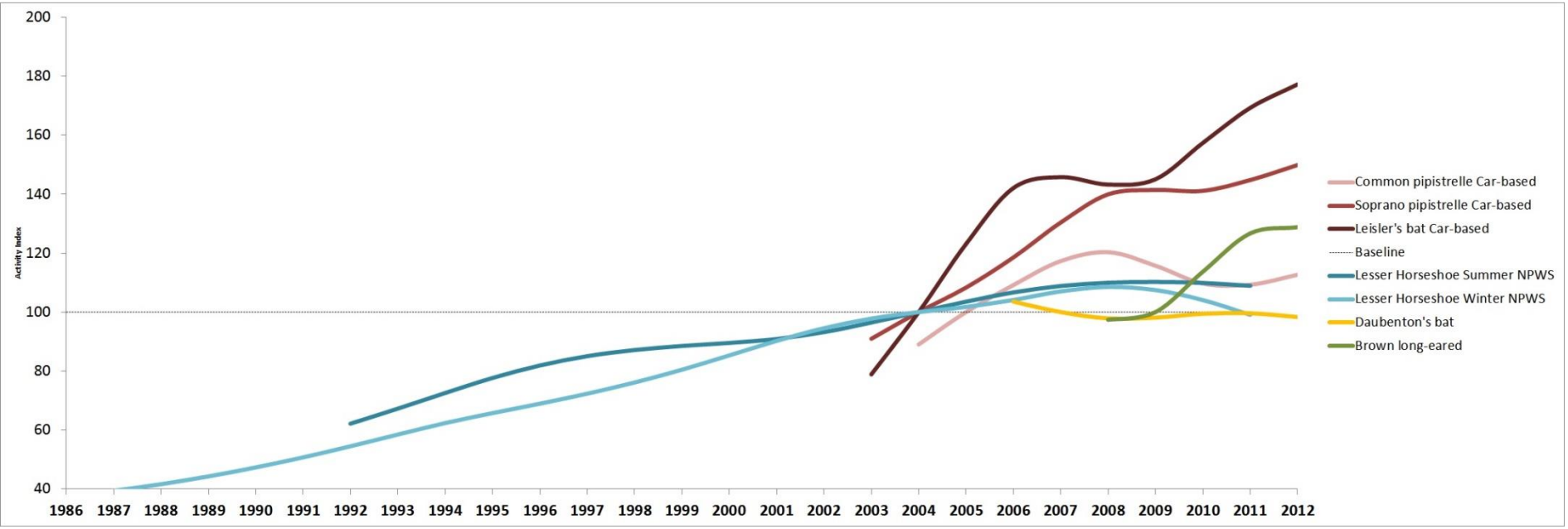
Photo: Kirsty Smith
http://creativecommons.org/licenses/by-sa/2.0/

"Common Redshank Tringa totanus" by Andreas Trepte - Own work. CC BY-SA 2.5 via Wikimedia Commons -

Larger bats avoid lit areas



Street Lighting Disturbs Commuting Bats Current Biology *19*, 1123–1127, July 14, 2009



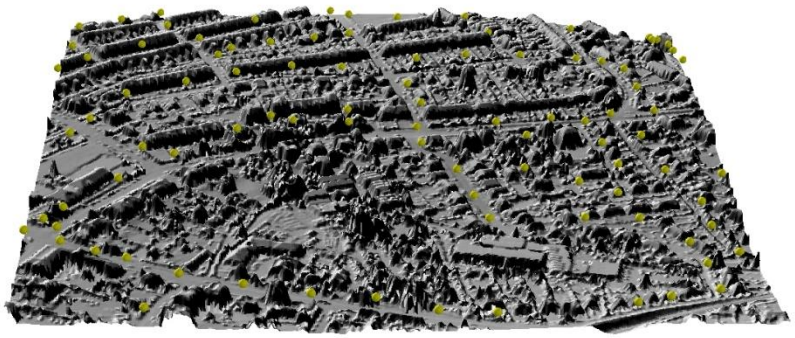
http://www.batconservationireland.org/

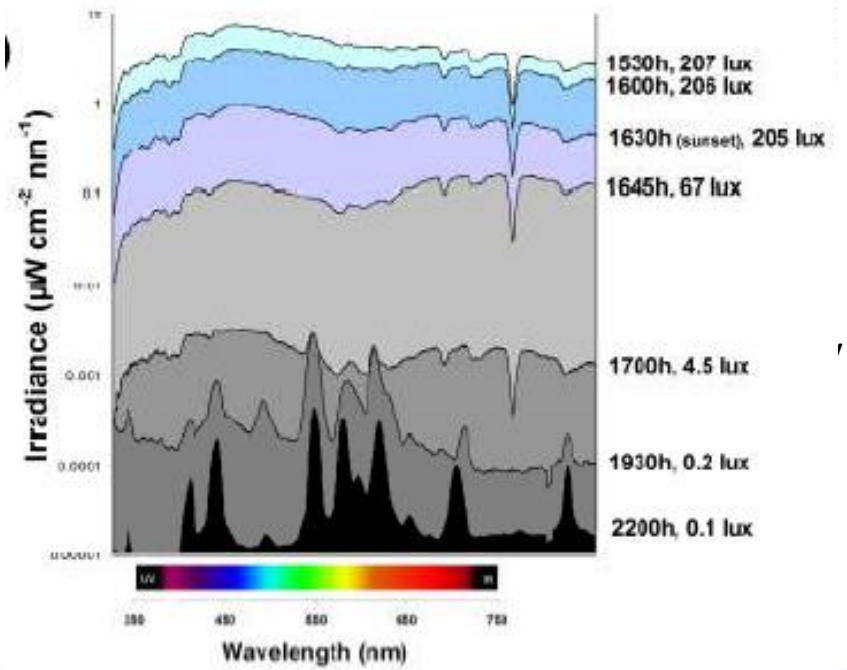
Changes in Irish bat population and diversity with time

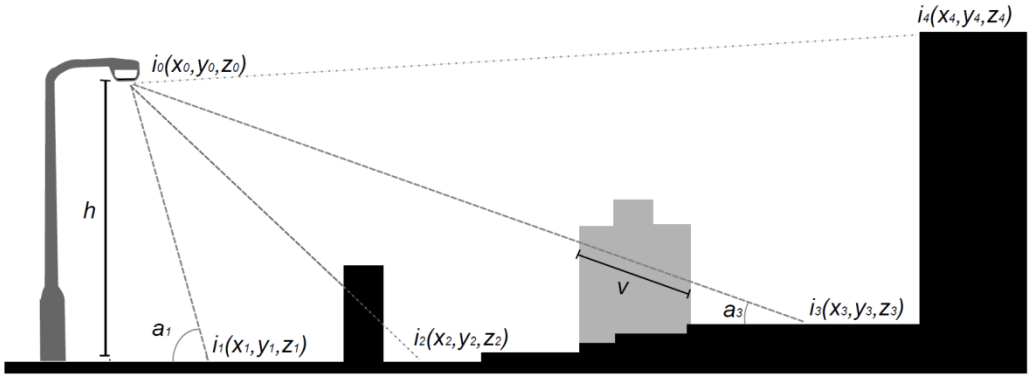
3D high resolution light modelling

How do organisms respond to:

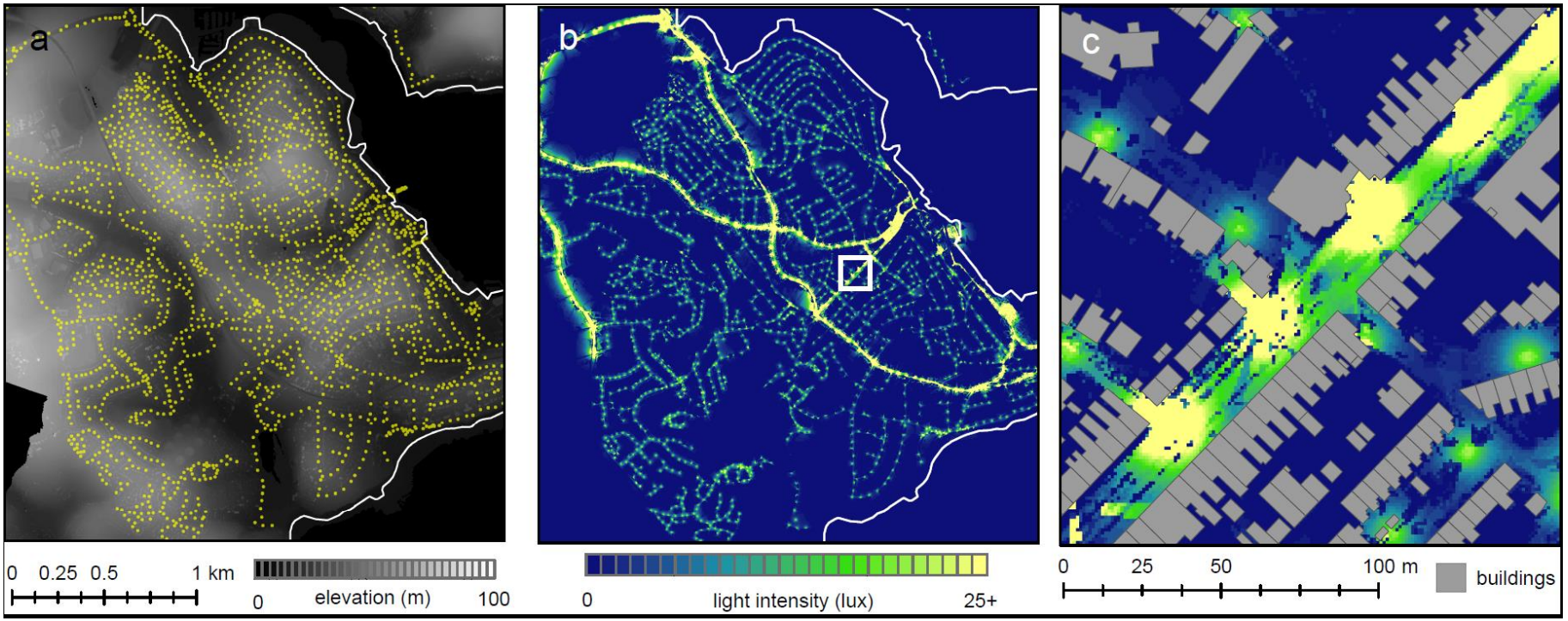
- fine-scale patchiness of light
- variation in spectral composition
- temporal changes







Potential landscape-scale effects of direct light in restricting movement



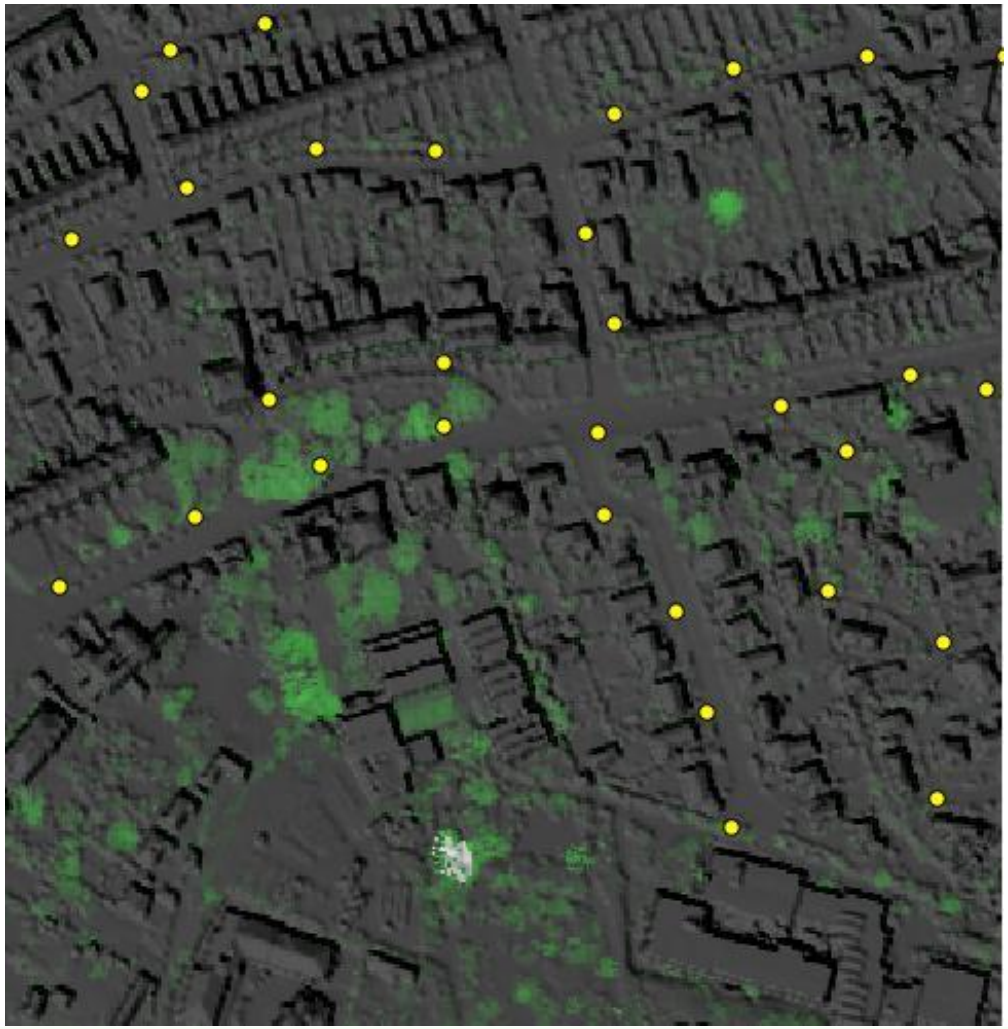

Local Nature
Reserve

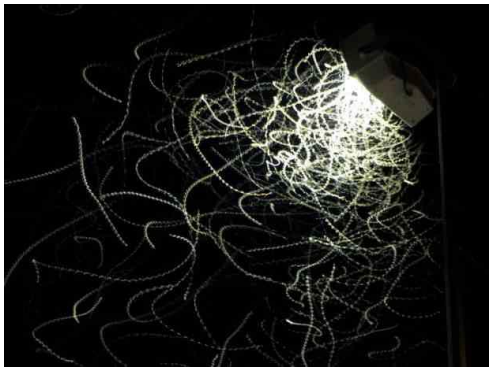
Innovative mapping of bat transit routes using electrical resistance analogy

0 100 200 300 400 500 m

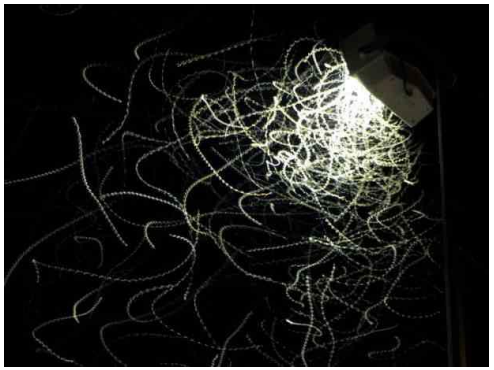
Bennie J, Davies TW, Inger R, Gaston KJ (2014) Mapping artificial lightscapes for ecological studies. ***Methods in Ecology and Evolution*** **5** 6 534-540

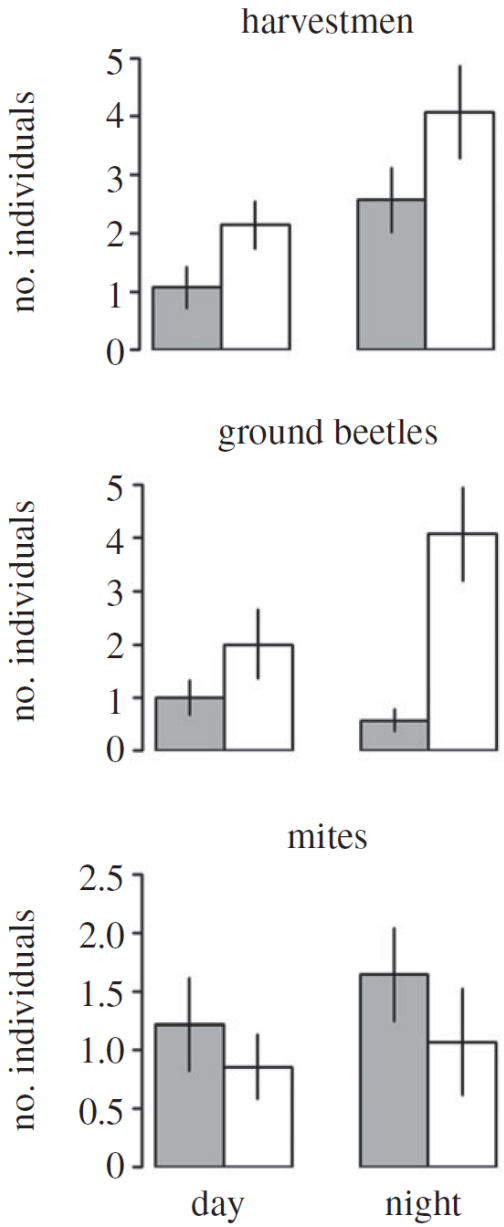
Modelling movement paths





Modelling movement paths



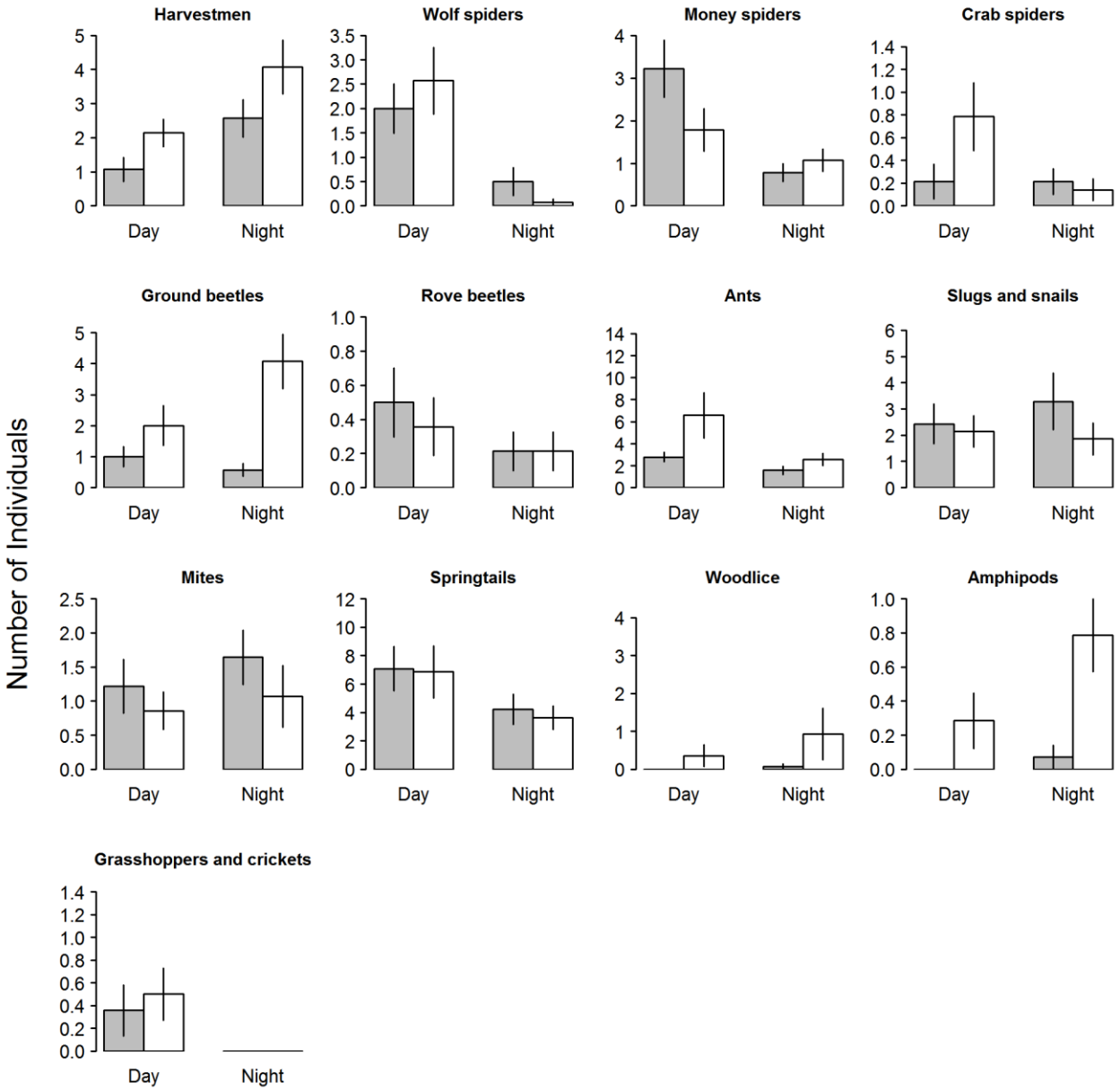


biology letters
Community ecology

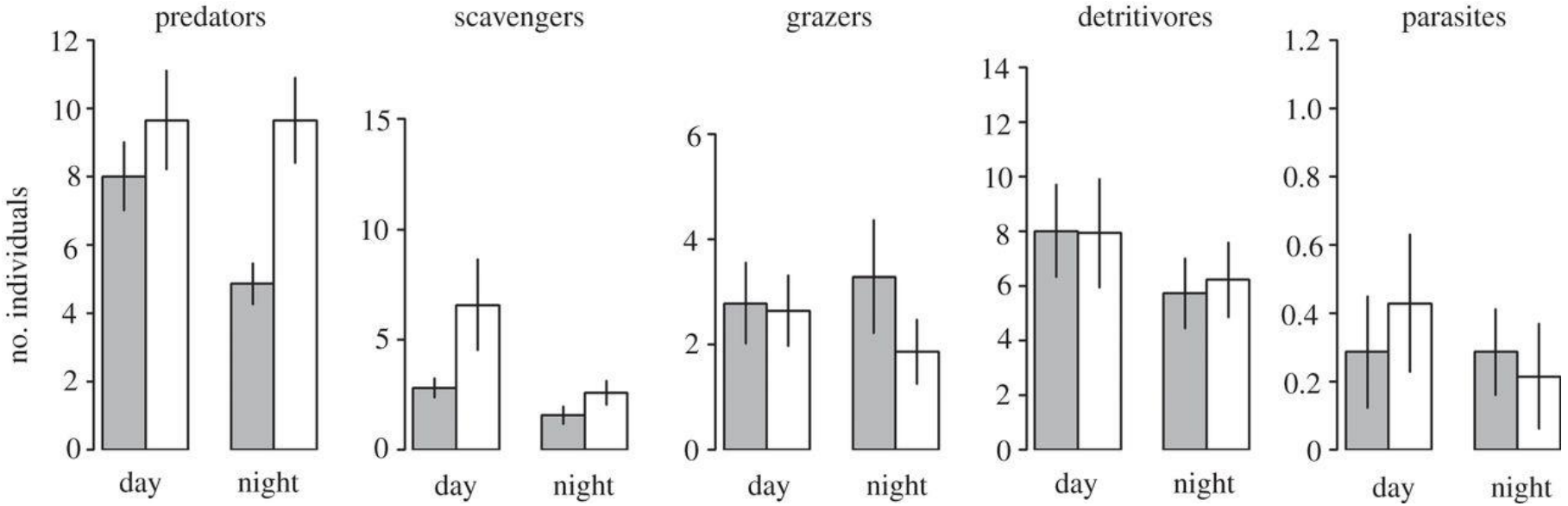
Biol. Lett.
doi:10.1098/rsbl.2012.0216
Published online

Street lighting changes the composition of invertebrate communities

Thomas W. Davies*, Jonathan Bennie and Kevin J. Gaston


Harvestmen
Wolf spiders
Money spiders
Crab spiders
Ground beetles
Rove beetles
Ants
Slugs and snails
Mites
Springtails
Woodlice
Amphipods
Grasshoppers and crickets
Day
Night
Number of Individuals

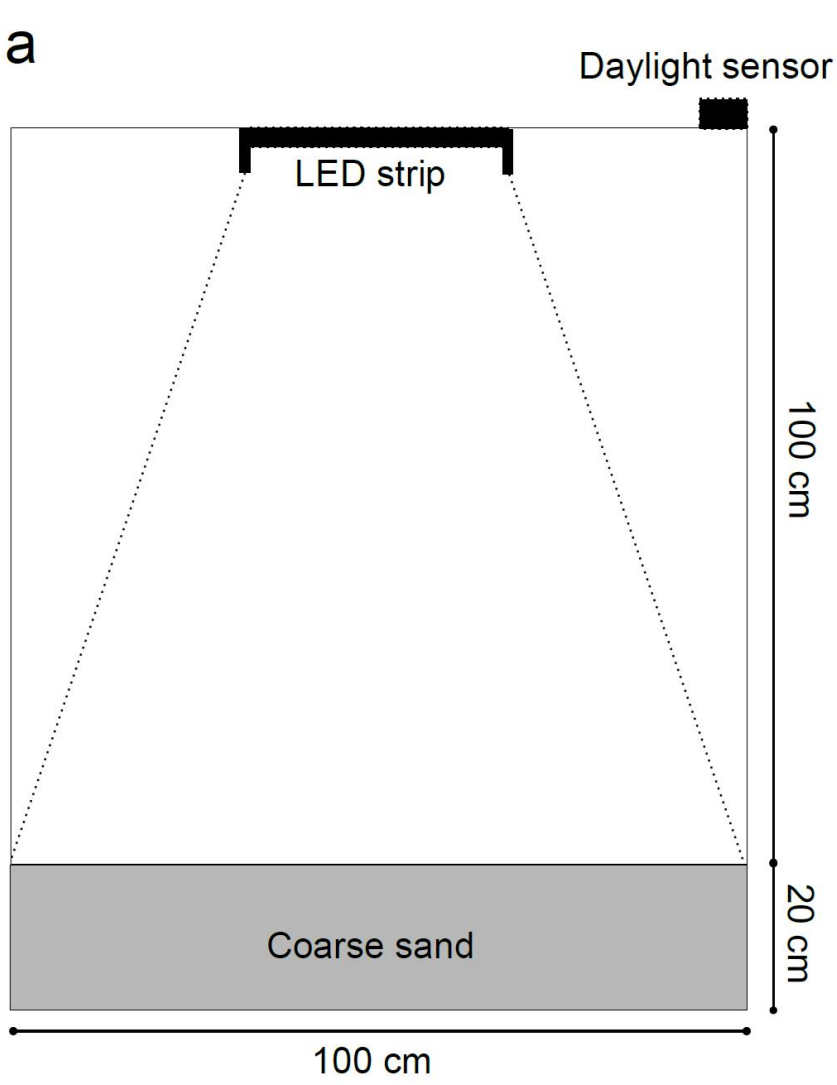
Community and population-level effects – potential for light at night to locally restructure communities



Exeter field experiment

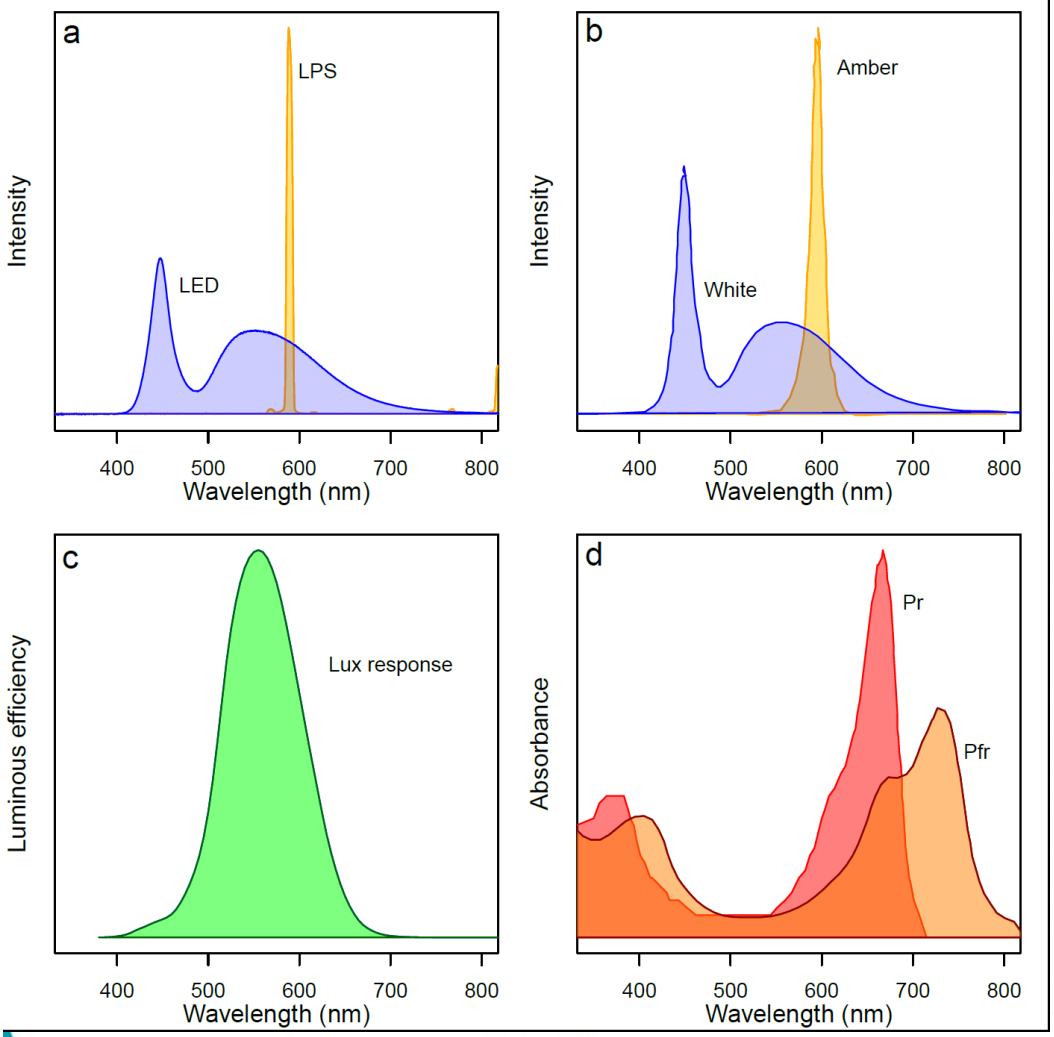
Exeter field experiment site

Mesocosm experiment


a
Daylight sensor
LED strip
100 cm
Coarse sand
20 cm
100 cm


b


c

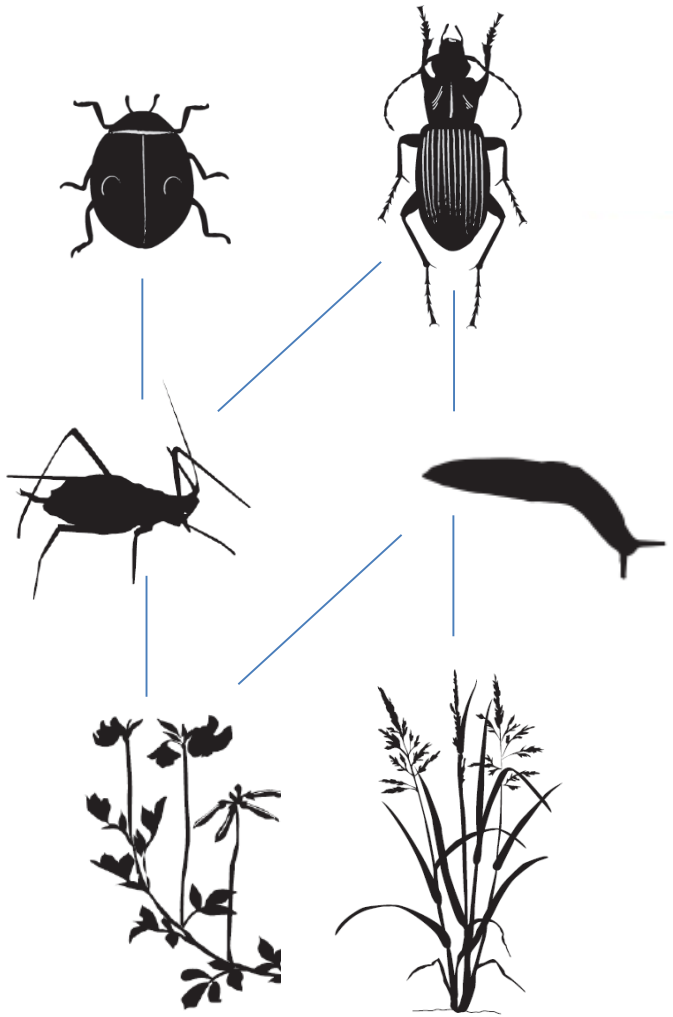

a
LPS
LED
Intensity
400
500
600
700
800
Wavelength (nm)
b
Amber
White
Intensity
400
500
600
700
800
Wavelength (nm)
c
Lux response
Luminous efficiency
400
500
600
700
800
Wavelength (nm)
d
Pr
Pfr
Absorbance
400
500
600
700
800
Wavelength (nm)


b


c

Cascading effects of artificial light at night: resource-mediated control of herbivores in a grassland ecosystem

Jonathan Bennie, Thomas W. Davies, David Cruse, Richard Inger and Kevin J. Gaston



Effects of artificial light on wildlife

Light as information:

- Interferes with detection of seasonal changes in daylength (tree budburst and leaf-fall; flowering in plants; breeding in birds)
- Alters detection of day and night (melatonin production in mammals and birds)
- Obscures natural cues for navigation (seabirds, night-flying insects)

Effects of artificial light on wildlife

Light as a resource:

- Increased activity of diurnal species (eg. songbirds) and some predators and foragers (owls, spiders, waders, pipistrelles around streetlamps)
- Reduced activity of light-shy species (eg. lesser horseshoe bat, rodents)

Light as a barrier:

- Fragments landscapes by repelling or trapping animals (eg.bats, moths)

Effects of artificial light on wildlife

Ecosystem effects:

- Effects of artificial light on seasonal timing may lead to mismatches between species
- Light may disrupt predator-prey interactions (top-down effects)
- Light may alter the availability of food resources (bottom-up effects)
- Light may alter other interactions between species (eg. nocturnal pollination)

Effects of artificial light on wildlife

Ecosystem effects:

- Artifical light may have unexpected consequences
- Acting together with other pressures – climate change, land-use changes, habitat loss

European Regional Development Fund
Investing in your Future

convergence
for economic transformation

University of Exeter

Thanks for listening.

Contact us:

j.j.bennie@exeter.ac.uk

k.j.gaston@exeter.ac.uk