

# ALAN 2015

3rd International Conference on Artificial Light at Night

May 29-31, Sherbrooke, Québec, Canada



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## FOREWORD

Dear ALAN participants,

Before the advent of electricity, nocturnal lighting was provided by the moon, oil torches and lanterns. Since then, nocturnal lighting has become more permanent and widespread, with the result that its intensity and duration are on the rise and mask the natural light cycles. Although lighting technologies came with tremendous benefits, however, sky visibility, wildlife, ecosystems and health are impacted by these changes. Use of lighting arises from the need for security, enhancement of the architectural and natural heritage, and commercial promotions. However, over-illumination is a real waste of energy and money and has many negative impacts on our nocturnal environment.

From those observations arose the challenge of better lighting design in order to reduce and control these side effects. Researchers, industry leaders and legislators like us must rethink light; hence the necessity of what we are doing today! To limit and reduce the misuse of light, lighting technology should be designed by controlling four characteristics on which it is possible to have control: 1- the amount of emitted light, 2- the orientation of emitted light, 3- the light spectrum of emitted light and, 4- the lighting period. Moreover, we also need to monitor and quantify the effect of old and new technologies to weight the pros and cons. To this end, biologists, physicists, mathematicians, engineers, programmers are all welcome to join this complex, but yet fascinating, field of work and research. By applying these principles, it will help to recover and preserve our nocturnal integrity and invaluable cultural heritage... dark starry skies.

ALAN is a trans-disciplinary conference which aims to address the possible side effects and environmental consequences of lighting through many topics: Technology and Design, Biology and Ecology, Modelling and Measurements, Society and Human Health.

ALAN 2015 presents 42 contributed communications and 8 invited talks of authors from 10 countries. ALAN 2015 will provide a unique opportunity to exchange and share on up-to-date research and new directions on many topics related to artificial light at night with international colleagues.

It is an honor to host this 3rd International Edition and I am pleased to welcome you in Sherbrooke (Québec, Canada). Sherbrooke is a city committed to preserving the nighttime environment. Indeed, the First International Dark Sky Reserve certified by the International Dark-Sky Association (IDA) was established in 2007 around the Mont-Mégantic National Park. After extensive street lighting conversion, Sherbrooke was part of it. 2015 has been declared the International Year of Light by UNESCO; this 3rd Edition is therefore of particular relevance.

On behalf of the ALAN 2015 Congress Organizing Committee, I would like to thank all of the authors for their contributions to the programme, all volunteers for their help in the organization of the conference as well as all sponsors for their financial support. I hope you will enjoy your conference and stay in Sherbrooke!

Sincerely,

Johanne Roby  
Coordinator, ALAN 2015



## INTERNATIONAL STEERING COMMITTEE

*Dr Christopher Kyba, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany*

*Dr Johanne Roby, Groupe de recherche sur la pollution lumineuse, Cégep de Sherbrooke, Québec, Canada*

*Dr Richard Stevens, Community Medicine and Health Care, University of Connecticut Health, United States*

*Dr Dietrich Henckel, Department of Urban and Regional Planning, Technische Universität Berlin, Berlin, Germany*

*Dr Maurice Donners, Philips Lighting, Eindhoven, Netherlands*

*Dr Franz Hölker, representative LoNNe (Lost of the Night Network)*

*Dr Martin Morgan-Taylor, Leicester De Montfort Law School, De Montfort University, Leicester, UK*

## LOCAL COMMITTEE

Light Pollution Research Group, Cégep de Sherbrooke, Québec, Canada

*Dr Johanne Roby, professor-researcher, Chemistry department (johanne.robby@cegepsherbrooke.qc.ca).*

*Dr Martin Aubé, professor-researcher, Physic department (martin.aube@cegepsherbrooke.qc.ca)*

*Pr Olivier Domingue, professor-researcher, Biotechnology department (olivier.domingue@cegepsherbrooke.qc.ca)*

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## PROGRAMME

<b>Friday, May 29</b>	
10h00-13h00	Registration Opens
<b>Introduction session</b>	
<i>Chair: Johanne Roby</i>	
13h00-13h15	<b>Welcome</b> <b>Johanne Roby</b> / Coordinator, ALAN 2015 <b>Mr. Jean Lussier</b> , eng. / Facilities Manager, Cégep de Sherbrooke
13h15-13h55	<b>Keynote speaker: Mr. Clifford Paul</b> , Society Moose Management Coordinator for the Unama'ki Institute of Natural Resources, NS, Canada. Mi'kmaq traditional knowledge including night sky stories <i>Title : Connectivity of Spirit</i>
13h55-14h35	<b>Invited talk: Mr. Pierre Goulet and Mr. Sébastien Guigère</b> , Society First International Dark Sky Reserve, Mount-Megantic, Quebec, Canada <i>Title : Fighting short wavelenghts at night: deployment of low-blue led lighting in the Mont-Mégantic International Dark Sky Reserve</i>
14h35-15h05	<b>Invited talk: Mr. Scott Feierabend</b> Executive Director, International Dark-Sky Association, leader in night sky preservation <i>Title : Together ... We Can Change The World</i>
<b>15h05-15h35</b>	<b>Coffee Break and Exhibition Stand visit</b>
<b>Plenary Session I</b>	
<i>Chair: Naomi Miller</i>	
15h35-16h05	<b>Invited talk: Dr. Kristan Aronson, Health</b> Public Health Sciences; Cancer Care and Epidemiology, Cancer Research Institute, Queen's University, Kingston ON, Canada <i>Title : Human health effects of exposure to light at night, with emphasis on biomarkers and breast cancer</i>
16h05-16h25	<b>Motta, Mario, Health</b> Tufts Medical School, Boston, MA, USA; Council of Science and Public Health, AMA <i>Title : Glare and Human Eye Physiology</i>

16h25-16h45	<p><b>Seitinger, Suzanne, Health</b>                  Philips Lighting, Burlington, MA, USA  <i>Title : Exploring metrics for ambient polychromatic light in interior settings for circadian support</i></p>	
16h45-17h05	<p><b>Dechesne, Roland G., Health</b>                  Royal Astronomical Society of Canada - Calgary Centre  <i>Title : ALAN and Schistosomiasis; A Potential Link</i></p>	
<b>~17h30</b>	<b>Departure for Mont-Mégantic Dark Sky Reserve</b>	
<b>~00h00</b>	<b>Return from Mont-Mégantic</b>	
<b>Saturday, May 30</b>		
<b>Plenary Session II</b>		
<b>Chair: Christopher Kyba</b>		
9h00-9h30	<p><b>Invited talk: Dr. Travis Longcore, Biology &amp; Ecology</b>                  Spatial Sciences Institute, University of Southern California, USA  <i>Title : Light Pollution as Global Change</i></p>	
9h30-10h00	<p><b>Invited talk: Dr. Andreas Hänel, M&amp;M</b>                  Planetarium Osnabrück, Museum am Schölerberg, Klaus-Strick-Weg 10, Osnabrück  <i>Title : Quantifying sky quality Measurement methods for sky brightness</i></p>	
<b>10h00-10h30</b>	<b>Elevator Pitch for poster and sponsors stands</b>	
<b>10h30-11h00</b>	<b>Coffee Break- marché de la Gare</b>	
	<p><b>Parallel Session I: M&amp;M</b>  <b>Chair: Martin Aubé</b></p>	<p><b>Parallel Session I: Technology &amp; Design</b>  <b>Chair : Suzanne Seitinger</b></p>
11h00-11h20	<p><b>Kyba, Christopher</b>                  Deutsches GeoForschungsZentrum GFZ,                  Postdam and Leibniz-Institut für                  Gewässerökologie und Binnenfischerei,                  Berlin, Germany.  <i>Title : Evaluating the systematic uncertainty                  of the Loss of the Night app</i></p>	<p><b>Dechesne, Roland.G.</b>                  Royal Astronomical Society of Canada -                  Calgary Centre.  <i>Title : Light Pollution from Greenhouses – a                  Global Problem with Some Possible                  Mitigation Strategies</i></p>



11h20-11h40	<p><b>Duriscoe, Dan</b> Night Skies Program, US National Park Service, Bishop, California, USA <i>Title: A database of night sky brightness photometry for U. S. National Parks</i></p>	<p><b>Schulte-Römer, Nona</b> WZB – Berlin Social Science Center <i>Title: LED lighting in Berlin and Lyon: How publics shape innovation</i></p>
11h40-12h00	<p><b>Walker Constance E.</b> National Optical Astronomy Observatory, Tucson, AZ, USA <i>Title: Intercomparing Methods of Night Sky Brightness Measurements</i></p>	<p><b>Morin-Paulhus, Antoine</b> Light Pollution Group, Cégep de Sherbrooke, Canada <i>Title: Spectral Indices based on biological processes sensitivity to handle lighting applications</i></p>
12h00-12h20	<p><b>Moore Chadwick</b> Night Skies Program Manager, US National Park Service, Fort Collins, Colorado, USA. <i>Title : Towards a More Comprehensive Bortle Classification System</i></p>	<p><b>Baddiley, Chris</b> British Astronomical Association Campaign for Dark Skies. <i>Title: Light pollution modelling for the UK Highways Agency new environmental impact policy, and for a sea based wind farm project</i></p>
<b>12h20-13h45</b>	<b>Lunch - Datoni Restaurant</b>	
	<p><b>Parallel Session II: Biology &amp; Ecology</b> <i>Chair: Olivier Domingue</i></p>	<p><b>Parallel Session II: Society</b> <i>Chair: Alejandro Sánchez de Miguel</i></p>
13h45-14h05	<p><b>Newman, Rhian C.</b> Organisms and Environment, School of Biosciences, Cardiff University, UK <i>Title : Artificial Light at Night in Freshwater Ecosystems</i></p>	<p><b>Adams, Mary Stewart</b> The Headlands International Dark Sky Park, Mackinaw City, Emmet County, Michigan, USA <i>Title: Once upon a time~Thinking Beyond the Telescope and Technology to Understand the Role of Natural Darkness in Developing Community</i></p>
14h05-14h25	<p><b>Da Silva, Arnaud</b> Max Planck Institute for Ornithology, Department Behavioural Ecology &amp; Evolutionary Genetics, Seewiesen, Germany. <i>Title : Singing from North to South: Latitudinal Variation of the Effects of ALAN on Timing of Dawn Song</i></p>	<p><b>Morgan-Taylor, Martin</b> Principal Lecturer in Law, de Montfort University, Leicester, UK. <i>Title : Global Approaches to the Regulation of Light Pollution</i></p>
14h25-14h45	<p><b>Azam, Clémentine</b> Natural History Museum of Paris, Paris <i>Title : The use of a French citizen database to analyze the effect of Artificial Light At Night on bats communities at different landscape scales.</i></p>	<p><b>Chapman, Mike</b> Sydney Outdoor Lighting Improvement Society (SOLIS). <i>Title: The future of lighting is better if it's dim. How the new technologies of lighting can be used for required and sufficient levels of illumination</i></p>

14h45-15h05	<p><b>Pendoley, Kellie</b>                  Pendoley Environmental Pty Ltd, Perth                  Western Australia  <i>Title : The Good, the Bad and the Ugly;                  Instrumental Light Measurement                  Techniques for Biological Studies</i></p>	<p><b>Ribas, Salvador J.</b>                  Parc Astronòmic Montsec, Consell Comarcal                  de la Noguera, Balaguer, Spain  <i>Title: First estimation of social and economic                  impacts of dark skies in Montsec</i></p>
15h05-15h25	<p><b>Shotbolt, Tim</b>                  Lighting Consultant, Australia  <i>Title : Koalas, Kookaburras, Marine                  Turtles, Iron Ore, Bauxite, Electricity,                  Trade, Travel, Prosperity, Growth,                  Legislation, International Agreements and                  Stars at Night in Australia</i></p>	<p><b>Pecingina, Mihai</b>                  International Dark-Sky Association, Quebec                  chapter, Canada  <i>Title: The control of the effects of the artificial                  light at night - doing its part</i></p>
<b>15h25-15h55</b>	<b>Coffee Break - marché de la Gare</b>	
<p><b>Plenary Session III</b></p> <p><b>Chair : Travis Longcore</b></p>		
15h55-16h15	<p><b>Kardel, W. Scott, Biology &amp; Ecology</b>                  International Dark-Sky Association, Tucson, Arizona USA.  <i>Title : Findings, Challenges, and Solutions: Restoring the Night Sky Gulf Coast Sea Turtle                  Restoration Project</i></p>	
16h15-16h35	<p><b>Dick, Robert, Biology &amp; Ecology</b>                  The Royal Astronomical Society of Canada, and the Canadian Scotobiology Group. Canada  <i>Title : Aiming High to Raise Awareness of ALAN in Protected Areas</i></p>	
16h35-16h55	<p><b>S. Mažeika, P. Sullivan , Biology &amp; Ecology</b>                  The Ohio State University, School of Environment and Natural Resources, USA  <i>Title: Community and ecosystem responses to artificial night lighting across                  aquatic-terrestrial boundaries</i></p>	
<b>17h15-18h45</b>	<b>Poster Session and cocktail hour and exhibition stand</b>	
<b>19h30-23h00</b>	<b>Conference Dinner- OMG Restaurant (1175 King Ouest, Sherbrooke)</b>	
<p><b>Sunday, May 31</b></p>		

<b>Plenary Session IV</b>	
<b>Chair:</b> <i>Nancy Clanton</i>	
9h00-9h30	<b>Invited talk: Dr. Will Straw, Society</b> Director, McGill Institute for the Study of Canada, McGill University, Qc, Canada <i>Title : Film noir after black-and-white</i>
9h30-10h00	<b>Invited talk: Ms. Naomi Miller, Technology &amp; Design</b> Designer/Senior Scientist, Pacific Northwest National Laboratory, Richland, WA, USA <i>Title : Pedestrian-Friendly Nighttime Lighting</i>
10h00-10h20	<b>Barentine, John, Society</b> International Dark-Sky Association, Tucson, AZ, USA <i>Title : The Rewards and Challenges of protecting International Dark Sky Places</i>
<b>10h20-10h50</b>	<b>Coffee Break - marché de la Gare</b>
<b>Plenary Session V</b>	
<b>Chair :</b> <i>Andrea Hänel</i>	
10h50-11h10	<b>Clanton, Nancy, Technology &amp; Design</b> Clanton & Associates, Inc. Boulder, Colorado, USA. <i>Title : Assessing than Mitigating (Skyglow Measurements to Lighting Ordinances)</i>
11h10-11h30	<b>Freyssinier, Jean Paul, Technology &amp; Design</b> Lighting Research Center, Rensselaer Polytechnic Institute, Troy, NY. <i>Title : Using Uniformity to Optimize Parking Lot Lighting</i>
11h30-11h50	<b>Welch, David, Society</b> Chair, Dark Skies Advisory Group, Urban Conservation Group, World Commission on Protected Areas, International Union for Conservation of Nature (IUCN) <i>Title: Protected places and the night sky, a match made in heaven</i>
11h50-12h10	<b>Sánchez de Miguel, Alejandro, Society</b> Dep. Astrofísica y CC. De la Atmósfera, Universidad Complutense de Madrid, Spain Light Pollution Group, Cégep de Sherbrooke, Canada <i>Title: Cities at night: a citizen science program to make a color map of the world.</i>
<b>12h10-13h30</b>	<b>Lunch - Datoni Restaurant</b>
<b>Plenary Session VI</b>	
<b>Chair:</b> <i>Dr Constance Walker</i>	
13h30-13h50	<b>Meier, Josiane; Henckel, Dietrich, Society</b> Technische Universität Berlin, Department of Urban and Regional Planning, Chair of Urban and Regional Economics, Berlin, Germany <i>Title: Lighting Conflicts: High Noon Ahead?</i>

13h50-14h10	<b>Dannemann, Etta</b> , Technology & Design Studio Dinnebier, Berlin, Philips Color Kinetics <i>Title: From concept to product – who decides on fixtures?</i>
14h10-14h30	<b>Rodriguez, Christophe</b> , Technology & Design Faculté de Génie, Université de Sherbrooke, Canada <i>Title : Improvement of LED performance by Increasing Light Extraction Efficiency: An example of how to stimulate college students to research in engineering through advanced micro-nano-fabrication improvements</i>
	<b>Mohar, Andrej</b> , Society Dark-Sky Slovenia, Slovenia <i>Title : Achievements and consequences of light pollution legislation in Slovenia</i>
14h30-15h00	<b>Johanne Roby, Martin Aubé and Christopher Kyba</b> <b>Open discussion, announcement for ALAN 2016, closing remarks</b>

## Poster

**Netzel, Henryka**

Institute of Astronomy, University of Wroclaw, Poland

*Title: Modelling of light pollution over Poland using Berry's model with high resolution data*

**Walker, Constance E.**

National Optical Astronomy Observatory, Tucson, AZ

*Title: Characterizing Night Sky Brightness In and Around Tucson and Nearby Observatory Mountaintops*

**Buchanan, Bryan**

Department of Biology, Utica College, NY, USA

*Title: Ecologically relevant amounts of artificial light at night can alter tadpole growth, development, and nocturnal activity.*

**Wise, Sharon E.**

Department of Biology, Utica College, Utica, NY, USA

*Title: The behavior of aquatic larvae and terrestrial juveniles of the Spotted Salamander (*Ambystoma maculatum*) is influenced by artificial light at night*

**St-John, Malcom**

Light Pollution Group, Cégep de Sherbrooke, Canada

*Title: Implementing Clouds into the Night Sky Radiance Model Illumina*

**Chapman, Mike**

Sydney Outdoor Lighting Improvement Society (SOLIS)

*Title: Sydney Outdoor Lighting Society*

**Dechesne, Roland G.**

Royal Astronomical Society of Canada - Calgary Centre, Canada

*Title: Strategies for Mitigating Light Pollution from Oil and Gas Field Lighting*

**Houle, Simon**

Light Pollution Group, Cégep de Sherbrooke, Canada

*Title: A satellite based intrusive light model*

**Lauzon, Andréa**

Light Pollution Group, Cégep de Sherbrooke, Canada

*Title: An Experimental Plate-form to study the impact of Artificial Light on flora*

**Sánchez de Miguel, Alejandro**

Dep. Astrofísica y CC. De la Atmósfera, Universidad Complutense de Madrid, Spain

*Title: Images from the Cities at Night program*

## Exhibition Stands

**Cégep de Sherbrooke**

**Astrolab, Mont-Mégantic, Canada**

**International Dark Sky Association**

**Philips Canada**

**LEKLA Canada**

**Cooper-Lighting by Eaton**

## ABSTRACTS

### KEYNOTE SPEAKER

#### Mr Clifford Paul



**Moose Management Coordinator** for the Unama'ki Institute of Natural Resources, Cape-Breton, Nova Scotia. Canada

He is well grounded in Mi'kmaq traditional knowledge, has an undergraduate background in science and has previously worked in professional communications. He is a superb public speaker and an excellent photographer. His passion is the bringing together of traditional knowledge and science, known as the Two-Eyed Seeing approach. He is also a major participant in youth outreach programs that involve holistic, out-of-doors experiences including night time sky stories.

For more information : <http://www.uinr.ca/>

***Title : Connectivity of Spirit***

“Everything that casts a shadow has spirit. Everything that has spirit deserves respect.” Through storytelling, photography, and art, Mi'kmaq presenter, Clifford Paul, will speak of his interactions and journeys within the natural world and how the stars, the sights, smells, sounds and beauty of Mother Nature keeps him grounded and connected with his ancestors. The presentation will offer a unique perception of how one's spirit is inspired by the pink and purple sunsets, night skies, crisp cool mornings, harsh land and seascapes, and the endearing people of Mi'kmaq territory.

## INVITED TALK

### Mr. Pierre Goulet



**Director** of Mont-Mégantic National Park, Québec, Canada

He is the pioneer of the *First International Dark Sky Reserve* at Mont-Mégantic, Québec, Canada.

### Mr. Sébastien Guiguère



**Scientific Coordinator**, ASTROlab of Mont-Mégantic, Québec, Canada

He is an education officer at the Mont-Mégantic national park and a scientific coordinator at ASTROlab. He is the author of the short film: “Rythmes cosmiques”, of the book “Le Mont-Mégantic: de la Terre aux étoiles” and of the exposition: “Du ciel étoilé à l'Univers infini”, along with numerous presentations and educational activities.

He is responsible for the lighting regulations at the *International Dark Sky Reserve of Mont-Mégantic*. He also collaborates on a regular basis with the media and has been implicated as a volunteer lecturer about climate change since 2008.

For more information: <http://ricemm.org/>

**Title :** *Fighting short wavelenghts at night: deployment of low-blue led lighting in the Mont-Mégantic International Dark Sky Reserve*

In 2008, the First IDA International Dark Sky Reserve was created in the Eastern Townships, Quebec, covering a territory of 5,500 km<sup>2</sup> and including 35 municipalities. The partner's efforts led to improved sky quality, reduced power consumption, and to a night environment featuring less glare, light trespass, and biological impacts. Despite the initial success, the Mont-Mégantic International Dark Sky Reserve (MMIDSR) had to re-launch its light pollution abatement project in 2011 in order to face new challenges. One of them was the mass introduction of blue-rich white LED lighting technology, with all of its advantages and drawbacks. Among the last, the fact that blue light at night is well known to cause more light pollution than other colours, thus threatening the reserve's hard gained achievements.

In keeping with the MMIDSR original approach, stakeholders then worked in a spirit of cooperation and joint action, to promote development and deployment of lighting solutions that are capable of addressing the needs of society, while also meeting dark-sky, health and ecological concerns.

In this presentation, we are happy to report that low-blue LED lighting (2% blue content) has been successfully deployed in at least 6 communities in the MMIDSR, including the 200 000 people city of Sherbrooke. Teaming with its partners, the MMIDRS calls for a global effort of the lighting and dark sky communities toward minimizing the blue content of artificial light at night.



## INVITED TALK

### Mr. Scott Feierabend



#### **Executive Director, International Dark-Sky Association (IDA)**

Since January 2015, Mr. Feierabend is the Executive Director of IDA. His professional conservation career began in 1980 as an intern with the National Wildlife Federation (NWF), where he held a number of positions, including staff scientist, lobbyist, director and vice president. Following a 21-year career with the NWF, he served as the director of conservation programs for The Nature Conservancy's Alaska Chapter.

He has published numerous scientific papers on a variety of conservation issues including California's native fish, the status of wetlands and lead poisoning in waterfowl and bald eagles. He is a native of Louisiana and received his Bachelor of Science in Biology from Emory University and Masters in Wildlife Biology from West Virginia University

For more information : <http://darksky.org/>

#### ***Title : Together ... We Can Change The World***

Founded nearly 30 years ago, the International Dark-Sky Association (IDA), headquartered in Tucson, Arizona (USA), is the world's leading non-profit organization advocating for the preservation of the night sky environment by protecting the planet from the adverse impacts of artificial light at night. We envision a world in which we use artificial light in the proper place, at the proper time, in the proper amount, and in the proper spectrum, thus improving human health, conserving wildlife, reducing energy use, and connecting future generations across the globe to their legacy of starry skies.

Like most agencies in the non-profit sector, IDA affects change at scale through strategies that “enable” and inspire individuals and concerned citizens to take action. Few, if any, non-profits have the financial resources and capacity to achieve mission directly, as a “doer,” and thus our strong reliance on partnerships, collaborations, volunteers, and grassroots to “get the job done.”

## INVITED TALK

### Dr Kristan Aronson



**Professor**, Public Health Sciences; Cancer Care and Epidemiology, Cancer Research Institute, Queen's University, Kingston ON, Canada

Her research interests are occupational exposures, air pollution, pesticides, shift work, light at night exposure, biomarkers, physical activity, sex hormones, and genetic variants as potential risk factors for cancer.

She is an epidemiologist conducting studies with collaborators around the globe to examine the relative contribution of environmental and genetic factors in the etiology of cancer, with the ultimate aim of prevention. She has held several senior scientific and administrative positions, career and research awards, and is also the recipient of the Golden Jubilee Medallion of Queen Elizabeth II in recognition of her volunteer peer review activities. She also works in India on projects addressing access to clean water in slums, and the dual problem of both under- and over-nutrition, and in Tanzania to reduce the incidence of cervical cancer.

For more information: [www.queensu.ca/cce/members/investigators/aronson.html](http://www.queensu.ca/cce/members/investigators/aronson.html).

### ***Title : Human health effects of exposure to light at night, with emphasis on biomarkers and breast cancer***

The rate of research on human health effects of exposure to light at night has increased rapidly in the past decade, especially with regard to cancer, cardiovascular disease and sleep disorders. In terms of cancer, in 2007 the International Agency for Research on Cancer (IARC) classified long-term shift work involving circadian disruption as a probable carcinogen, based on “sufficient evidence in experimental animals” and “limited evidence in humans.” Citing limitations in the consistency of measurement of light at night exposure for workers, in 2009 an IARC Working Group suggested better characterization of exposure including shift system (type of shift, direction of rotation, number of consecutive nights); number of years on specific shift schedules and cumulative exposure over the working life; and, shift intensity (number of days off between work days). Others have also suggested additional considerations of length of time on shift, and social aspects of the working hours.

This presentation will start with a brief review the current state of knowledge of human health effects associated with light at night, and criteria for judging cause-effect relationships. Our research program in the environmental and genetic causes of cancer with regard to exposure to light at night will be described, highlighting key findings. To elucidate potential mechanisms relating exposure to light at night to health outcomes, our biomarker research on melatonin and cortisol among working nurses will also be presented. Challenges in conducting human studies will be explored, with suggestions for improved future research including measurement of ambient light at night. While there is mounting epidemiologic evidence of health effects potentially caused by light at night exposure and increased understanding of the specific mechanisms is still needed, mitigation/prevention strategies need urgent consideration.

Acknowledgements: Canadian Institutes for Health Research, Workers Safety and Insurance Board (Ontario), and many students, co-investigators, and collaborators.

**Author:** Mario Motta, MD, FACC.

**Institutions:** Associate Professor Medicine, Tufts Medical School, Boston, MA, USA; Council of Science and Public Health, AMA; member of the Board of the International Dark Sky Association (IDA); New England Light Pollution Advisory Group (NELPAG), Past president of both the Massachusetts Medical Society, and the AAVSO

**Email:** mmotta@massmed.org

**Title:** *Glare and Human Eye Physiology*

Glare is a significant problem on roadways for drivers, and gets progressively gets worse as the human eye ages. The effect of glare at age 60 is 3 times the affect at age 20. The human eye is a marvel of engineering, but has several design flaws. The human lens has no intrinsic blood supply, but continues to grow by layers throughout life. The lens derives its oxygen and nourishment by diffusion from the surrounding fluid of the eye. Eventually diffusion on its own is not sufficient due to growth of the lens and the center of the lens degenerates, forming focal calcifications and eventual cataracts. In addition, when bright light hot spots are in the field of view, the human pupil constricts leading to less light reaching the retina. The retina also loses its night adaptation with glare lighting. These cause night vision to deteriorate, leading to the perception that there is not enough light on the roadway. These are the fundamental reasons why nighttime vision is impaired. The solution is not more lightning, but rather avoidance of poor lighting designs, by taking into account human physiology. In my opinion, proper lighting design should not be based solely on “foot candles” on the ground (the current standard), but rather should incorporate human physiologic testing to show whether the proposed lighting design in fact improves vision, or as is currently the case with many lighting fixtures, actually impedes proper vision, and are in fact road hazards.

I have long been an advocate for Light Pollution mitigation efforts. With my election as a delegate to the American Medical Association (AMA) representing the Massachusetts Medical Society (2003), and subsequent election to the AMA Council of Science and Public Health (2008), I was able to write and promote resolutions for the AMA that adopted strong Light Pollution policy. In 2008 the AMA adopted as policy the recommendation that all street lights be fully shielded. In 2012, a 35 page Light Pollution Monograph with 134 peer reviewed reference papers as supporting data was adopted that links poor nighttime lighting with deleterious health effects. These policy positions, in combination with strong economic arguments for energy savings, can be extremely useful to convince governmental bodies such as city councils to adopt proper lighting practices. I have been very successful in promoting fully shielded lighting utilizing these arguments and methods, and will present the data and useful talking points for attendees.

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**Title:** *Exploring metrics for ambient polychromatic light in interior settings for circadian support*

The discovery of the intrinsically photosensitive retinal ganglion cells in the eye led to a resurgence of research on how light can impact human health, specifically circadian rhythms. In an effort to explore new approaches to lighting, researchers are increasingly going beyond laboratory settings and instead using more natural settings. Our presentation explores how various metrics for evaluating the potential for circadian stimulation lead to different design directions for interior, artificial lighting.

We first review an experiment conducted with B Roberge<sup>a</sup>, F Sert-Kuniyoshi PhD<sup>b</sup>, DP White MD<sup>b,c</sup> and S Pittman MSBME<sup>b</sup> to examine the effect of polychromatic light on the partial endogenous salivary melatonin concentration curve in a natural interior setting using solid-state lighting technology. During a single center within-subject controlled study, we found no effect on the endogenous salivary melatonin secretion with a specially designed red/amber-shifted evening light mode. However, blue-enriched morning light mode affected the photic suppression of endogenous salivary melatonin secretion. The protocol was repeated with more comfortable white light settings. Melatonin levels stayed the same under the amber light and dropped under the blue-white light.

Starting from these results, we analyze both the experimental and several additional lighting conditions using Lucas et al.'s (2014) "melanopic equivalent lux" and Rea et al.'s (2005, 2012) circadian stimulus metric. We discuss how these different light settings compare and might be implemented in specific interior settings. For practitioners, we recommend increased collaboration among disciplines to ensure that more metrics are compared and explored for measuring effects on the human circadian system and integrating biological with visual needs.

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**Title:** *ALAN and Schistosomiasis; A Potential Link*

The World Health Organization indicates that the parasitic disease, schistosomiasis, afflicts nearly 240 million people in tropical and semitropical climates worldwide. The disease is caused by parasitic flatworms, or flukes, of the *Schistosoma mansoni* or *haematobium* types. These may infect the urinary tract or intestines and in those who have been infected a long time, liver damage, kidney failure, infertility, or bladder cancer may occur. In children it can cause poor growth and learning difficulties. Schistosomiasis is second only to malaria as a parasitic disease with the greatest economic impact. The annual death rate is very poorly constrained at between 12,000 and 200,000 cases.

Schistosomes have a vertebrate-invertebrate host lifecycle, with snails being the typical invertebrate host. Within snails, several transformations and divisions of the organism occur, giving rise to a large number of cercariae that infest the snail. Once released from the snail, cercariae penetrate the skin of human hosts (and other mammal or avian hosts for other species of schistosomes, e.g. those that cause ‘swimmer’s itch’) and after another metamorphosis, migrate to the lungs and thence to the liver where they proceed to feed on red blood cells.

The behavior of snail’s cercariae is strongly controlled by light and their dispersion from their snail hosts follows a circadian pattern and is most prevalent during the day. On top of this, their proliferation within their snail hosts is also circadian and also occurs primarily during daylight hours. This proliferation and dispersal pattern can be manipulated by reversing the timing of light and dark by artificial light (Giovannola 1936). Nojima and Sato (1982) demonstrated that for *S. mansoni*, a short dark night period led to an increase in cercarial shedding relative to a baseline value. These experiments show that ALAN has the ability to extend the proliferation stage of the cercariae in snails.

Additionally, according to Barbosa *et al.* (1987), the snail host of *S. mansoni*, *Biomphalaria Glabrata*, showed highest reproductive rates, in terms of total number of eggs, clutches and hatching, under constant illumination, with lower numbers for each of these measures under conditions similar to natural day – night cycles. The greatest reduction in reproduction occurred in constant darkness. In summary, reproductive rate was dependent on both the intensity of illumination and the schedule of illumination exposure.

Taken together, these studies show that ALAN has the potential to increase both the total number of host snails, and the reproductive capacity of schistosomes infecting those snails in regions that are likely to be densely populated. While modernization may have the potential to improve lives in the developing world, widespread light pollution near water bodies containing schistosomes and their snail hosts could lead to a mixed outcome in terms of this widespread parasitic disease.

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## INVITED TALK

### Dr Travis Longcore



**Associate Professor**, Spatial Sciences Institute, Dana & David Dornsife College of Letters, Arts and Sciences, University of Southern California

His research interest is urban ecology and conservation, with emphasis on conservation planning and management, edge effects of development, especially artificial night lighting, and monitoring and management of endangered species.

He is co-editor of the book *Ecological Consequences of Artificial Night Lighting* (Island Press, 2006) and author of over 25 peer-reviewed articles in journals such as *Conservation Biology*, *Biological Conservation*, *Restoration Ecology*, *Environmental Management*, *Urban Geography*, and *Frontiers in Ecology and the Environment*. His research has been covered in *National Geographic*, *Audubon*, *New York Times*, *Wall Street Journal*, *Life*, and *Discover*. His current research addresses the issue of spectrum in mitigating the attraction of insects to lights. He also serves as the Science Director of The Urban Wildlands Group.

For more information : <http://spatial.usc.edu/?team=travis-longcore>.

### ***Title : Light Pollution as Global Change***

In just over a century since the invention of the electric light bulb, broad swaths of the planet have been transformed from experiencing a natural pattern of light and dark determined by the sun, moon, stars and occasional other transient lights, to being subjected to intermittent and perpetual illumination from human civilization that is unprecedented in the history of Earth. The pervasiveness of this phenomenon and its exponential growth should merit recognition as a global change: a planetary-scale change in the Earth system. The results of recent research have extended knowledge about the geographic scope and specific impacts of artificial night lighting on animal behavior, physiological processes, and ecological interactions across a range of taxa, its broader ecosystem effects, and its consequences for human wellbeing.

## INVITED TALK

### Dr. Andreas Hänel



Museum am Schölerberg, Planetarium, Osnabrück, Germany

His main interest is communicating astronomy and the problem of light pollution to the general public. The scientific interest is mainly in measuring techniques for monitoring night sky brightness.

He has studied physics and astronomy at the observatory of Bonn university and worked at different astronomical observatories, like Haute Provence/France, La Silla/Chile, Roshen/Bulgaria. He is director of the planetarium in the natural science museum Osnabrück and lecturer for astronomy at Osnabrück university. He was working for more than 20 years on light pollution. During the last years he worked on setting up the first dark sky places in Germany which created a great interest in the national media.

For more information : [www.lichtverschmutzung.de](http://www.lichtverschmutzung.de).

#### ***Title : Quantifying sky quality Measurement methods for sky brightness***

Accurate measurements of the sky brightness are essential for monitoring the status and changes in light pollution. They are also important for classifying dark sky protected sites. We will present the different measurement methods from simple visual estimations like the Bortle scale or limiting magnitude to sophisticated spatial and spectral resolved methods. The classical astronomical approach to measure faint sky background brightness will be compared to the photometric luminance measurements at bright light levels. Problems and differences between simple point and two dimensional spatial resolved measurements will be discussed as well as interrelations.

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**Title:** *Evaluating the systematic uncertainty of the Loss of the Night app*

The Loss of the Night app allows citizen scientists to estimate the brightness of the faintest stars that can be seen in the night sky (naked eye limiting magnitude). In typical clean atmospheres, this value is highly correlated with the amount of artificial skyglow in the night sky (Kyba et al. 2013). We present a maximum likelihood algorithm for calculating the internal consistency of a single app observation. We also evaluate the systematic uncertainty associated with an individual skyglow measurement by comparison of app observations to measurements taken with Sky Quality Meters, and the predictions of skyglow models (Cinzano et al. 2001, Cinzano & Falchi 2012).



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**Title:** *A database of night sky brightness photometry for U. S. National Parks*

A large database of high resolution all-sky measurements of V-band night sky brightness at sites in U.S. National Parks is presented. These observations were made from 2001 to 2015 and include 1500 individual data sets from 456 nights at 315 sites in 136 park areas throughout the United States. A customized natural sky brightness model for each data set was constructed and subtracted from the measurements; the remainder is a photometrically calibrated estimate of the distribution of artificial sky glow over the hemisphere. Indicators of night sky quality are also presented for each data set. This database, with its striking panoramic images readily revealing the effects of artificial sky glow, provides a valuable resource for verifying sky glow models, examining variation in the natural sources of sky brightness over the solar cycle, use as a baseline for long term monitoring, and assessing the impact of light pollution on protected areas. Images and data tables are accessible on a public website.

<http://www.nature.nps.gov/night> or <http://www.nps.gov/orgs/nsnsd/index.htm>

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**Title:** *Intercomparing Methods of Night Sky Brightness Measurements*

The focus of the research was to find out how well different types of instruments that measure night sky brightness inter-compare. The different instruments used in the study were: a digital single-lens reflex (DSLR) camera, three handheld Sky Quality Meters (SQM model L or SQM-L), SQM-UL-DL+H stations, a Night Sky Brightness Monitor (NSBM), the “Loss of the Night” (LON) application for Android phones, the “Dark Sky Meter” (DSM) application for iPhones, and the Globe at Night web application that records the “Naked Eye Limiting Magnitude” (NELM). Sixteen locations were identified throughout the city of Tucson and surrounding areas for taking measurements. The locations had a complete range of sky brightness conditions and included parks, highly populated areas, and observatory mountaintops. As expected, the three SQM-L and the SQM-UL-DL+H data compared well with one another to the 99 percentile using the  $R^2$  coefficient. The NSBM on Mt. Hopkins also compared well (91%) with the SQM-L data. The DSM app gave a 93% correlation to SQM-L data. The DSLR camera data provided an 80% correlation to the same data set. The Globe at Night NELM method had a 75% correlation with the SQM-L data. And the LON app data had a 43% correlation. Results will be reviewed.

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**Title:** *Towards a More Comprehensive Bortle Classification System*

In 2001, longtime amateur astronomer John Bortle described the night sky in nine classifications, from 1 (pristine) to 9 (inner-city sky). The “Bortle Dark-Sky Scale” has become accepted and is generally used to communicate the level of anthropogenic light and sky quality to the lay public. In this presentation, we relate each Bortle Class to a broad array of visual observations and photometric measurements. This should better enable the transformation between qualitative description and quantitative values, and articulate functional consequences associated with various levels of sky brightness.

We will also present for discussion a work in progress dichotomous key and more rigorous protocol of making assessments of sky quality.

John Bortle, Sky and Telescope Magazine, February 2001. (<http://www.skyandtelescope.com/astronomy-resources/light-pollution-and-astronomy-the-bortle-dark-sky-scale/>)

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**Title:** *Light Pollution from Greenhouses – a Global Problem with Some Possible Mitigation Strategies*

Today, many greenhouse operations have become significant sources of light pollution as greenhouses have changed from passive solar collectors providing a clement temperature environment for plant growth to increasingly technologically advanced systems that, with computer-controlled hydroponics and supplementary lighting systems for maximizing the growth potential of the crops' circadian rhythms.

While it may seem obvious that many plant crops need sunlight to grow, in many regions where natural sunlight may be limited at times due to overcast conditions (Netherlands, United Kingdom, lower mainland British Columbia, Canada) or due to seasonal deficiencies (United Kingdom, Canada and Iceland), supplementary lighting is need for optimum productivity. As lighting efficiencies have improved beyond incandescent fixtures, more and more greenhouses world-wide have incorporated supplementary lighting, with the efficiencies realized with High Pressure Sodium (HPS) lamps apparently being a sort of 'tipping point' so that this technology was widely adopted. Unfortunately, it has been estimated that only about 7% of the light output of HPS lamps is effective for plant growth, with the remainder lying in parts of the visible light spectrum that provides no useful energy for crop growth and maturation.

Research on the action spectra of the various compounds found in chlorophyll, together with experimental work on plant crops with lamps of various spectral outputs is now providing insights on the best way to use supplemental lighting in greenhouses to variously select for compact or extended growth, quick flowering or suppressed flowering, depending on the desired outcome. Certain spectral characteristics have also been shown to suppress insect pests.

LED illumination is quickly taking over supplemental lighting from HPS not just because of energy efficiencies but because of the ability to target the correct wavelengths in their outputs. Thus LED illumination might become even more ubiquitous than HPS, but if implemented properly, a greater fraction of the emitted light spectrum will be absorbed by the crops. LED's efficiencies are now to the point where even the mainstay of greenhouse lighting, natural sunlight, might be dispensed with in the name of circadian rhythm manipulations on time frames of less than 24 hours inside totally sealed buildings.

Until then, other methods to reduce light pollution from greenhouses include wall and top screens, semitransparent solar photovoltaic layers and diffusion films. Dutch legislation requires an opaque screen that reduces light transmission of the greenhouse wall by 95%. Since 2008, the light transmission of the greenhouse roofs there must be reduced equally and supplementary light will be limited to 15,000lx (180 $\mu$ mol/m<sup>2</sup>/s).

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**Title:** *LED lighting in Berlin and Lyon: How publics shape innovation*

This paper is based on my doctoral thesis and focuses on the introduction of LED street lighting in cities. It explores how the choice and design of technological solutions is influenced by concrete urban situations. In line with critical social-scientific studies on science, technology and society (STS) I argue that the technological innovation is shaped by social processes and cultural configurations. This argument is developed on the basis of ethnographic case studies on LED projects in Lyon (France) and Berlin (Germany).

In terms of public lighting, these two European cities could not be more different: Lyon is world-wide renowned as a ‘City of Light’ and is currently exploring adaptive LED lighting systems. Berlin has gained the reputation of a dark place and is cultivating its 19<sup>th</sup> century gaslights. In my paper, I outline how these different urban innovation and regeneration strategies relate to the organizational and political situations in Lyon and Berlin.

Another, even more interesting finding of my research is that these two different approaches regarding LED lighting are also linked to city-specific publics for urban lighting. While the Lyon lighting practice is acknowledged by an international expert audience, Berlin’s public lighting service is observed and criticized by local politicians and civic movements that fight for the preservation of West Berlin’s gaslights. Based on my observations and comparative analyses I thus conclude that technological innovations like LED lighting are not only shaped by their producers and direct users, that is lighting services, installers and light planners, but also by their wider publics. These publics are not identical with those people who are affected by public lighting in urban spaces—after all, public lighting infrastructures and services are mostly taken for granted and ‘invisible’ so that lay audiences often do not care. Instead, I argue that publics are city-specific: They form and emerge around both local and global issues and thereby affect innovation processes. Against this background, we can also further ask how current discourses about light and health, light nuisance or ‘nocturnal urbanism’ and light-related controversies, as they will be discussed during the ALAN 2015 conference, also constitute publics that affect technological developments in lighting.

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**Title:** *Spectral Indices based on biological processes sensitivity to handle lighting applications*

Artificial light has impacts on many biological processes which are highly linked to the spectral content of the light. The parameters that currently exist to characterize lighting such as color temperature (CCT) and color rendering index (CRI) values give little information about the spectral composition of light and its possible impacts on health and environment. The understanding of the impact of artificial light on biological processes and the environment has evolved significantly since the last decades. Many biological processes are linked to the spectral content of the light with their own sensitivity. We need new tools to better understand the relation between artificial light and biological processes. Our research group aimed to provide basic tools to facilitate studies of artificial light impacts on environmental and health impacts with the development a light spectral database.

During this talk, we will present how we could help authorities and population to manage the lighting using three indices developed by our research group: 1- melatonin suppression index, 2- Induced photosynthesis index, and 3- star light index. Those indices are based on the spectral composition of artificial light and the spectral sensitivity of biological processes. We will also present how we could extend the concept of the indices to other biological processes such as the attractiveness of insects and bats in the light. In parallel, our research group is working to develop a light spectral database intended to provide, to the scientific community, basic tools to facilitate studies of artificial light on environmental and health impact. The data base contain the spectral power distribution of a large variety of commercial light bulbs or luminaires along with associated correlated color temperature, blue content (from 405 to 530nm) and the three spectral indices described above. We will also present how to use the online lamp spectral distribution database and we will summarize some correlations between CCT, Blue light content and the spectral indices. We would like to invite the scientific community to contribute to the spectral database.

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**Title:** *Light pollution modelling for the UK Highways Agency new environmental impact policy, and for a sea based wind farm project.*

The Highways Agency are replacing their policy of full cut off class G6 road lighting specification on motorways, and are adopting a categorised environmental impact based point system that can accommodate technical advances, such as LED lighting. The Skyglow component of this will be based on the modelling of skyglow versus cut-off angle, developed for determining the relative light pollution environmental impact of different streetlight designs. Further modelling has been done concerning the effect of LED lighting, which potentially, has highly directional properties. But increasingly used blue rich colour temperatures are likely to increase skyglow by at least 5 fold, compared to traditional lighting. This is due to enhanced reflection of vegetation and greatly increased atmospheric molecular Rayleigh scattering. This is a potential astronomical environmental disaster in the making.

The paper also describes the results from the same model adapted to study the night-time environmental impact of a proposed wind farm project as a part of the planning process. It would have many navigation and aviation warning lights on the turbine masts, covering a grid of over 10 km a side, which would be visible from the adjacent coast some 15 km away. The results are compared with a typical dark rural environment.

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**Title:** *Artificial Light at Night in Freshwater Ecosystems*

Artificial Light at Night (ALAN) is among the fastest growing anthropogenic influences on the natural environment, yet there are major gaps in current knowledge about its effects on most animals. This is particularly true in freshwater ecosystems of which many have close proximity to sources of artificial light.

This study sought to determine the impact of high-pressure sodium lighting on the physiology and behavior of a wild freshwater fish of high economic and conservation value (Atlantic salmon, *Salmo salar*) and their invertebrate prey. In combined experimental field and laboratory studies, we examined the influence of ALAN on daily patterns of refuging and foraging behavior of salmon parr, the cortisol stress response of dispersing salmon fry and the nocturnal drifting behavior of freshwater invertebrates, the primary food source of freshwater drift feeding fish.

The results will be discussed in relation to predator-prey interactions in freshwater ecosystems. We argue for a better evidence-based understanding of the influence of light pollution to inform policy decisions and management of light regimes affecting Rivers.



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**Title: Singing from North to South: Latitudinal Variation of the Effects of ALAN on Timing of Dawn Song**

Previous work showed that artificial night lighting led to an earlier start of dawn song in many European songbird species. However, these studies were carried out at a particular latitude, and we still lack an understanding of the impact of light pollution in relation to variation in natural light conditions. The aim of our study was to investigate the influence of artificial light at night on the timing of dawn singing of five common songbird species at three study sites in Europe that differ in natural daylength variation. In 2014, we selected five peri-urban forest patches with and five without light pollution (street lights) in each of three locations: around Oulu, Finland (65°N), around Starnberg, Germany (48°N), and around Granada, Spain (37°N). We recorded dawn singing from three weeks before until one week after the mean start of egg-laying of local great tit populations (from 25 March to 18 April in Germany and Spain, and from 2 to 26 May in Finland). Our results show that the strength of the effect of artificial night lighting on the start of dawn singing depends on the latitude and on the species. The light effect does not depend on latitude in great tits, where it advances dawn song by on average 40 min at all sites, and in blue tits and chaffinches (the latest natural singers), where it has no significant effect. However, in robins and blackbirds (the earliest natural singers), dawn singing is advanced by light pollution by on average 30 min in the intermediate and southern latitude, but this effect is absent at the more northern site. This is because robins and blackbirds already sing much earlier at the control sites in the north, such that light pollution has no added effect. We discuss the implications of our findings in the context of the fitness effects of singing at night for diurnal songbirds.

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**Title:** *The use of a French citizen database to analyze the effect of Artificial Light At Night on bats communities at different landscape scales.*

The effect of Artificial Light At Night (ALAN) on biodiversity is of growing concern in conservation biology. As nocturnal mammals, bats may be particularly sensitive to this anthropogenic disturbance. Bats response to ALAN has however appeared to show strong interspecific variations, being either positive or negative according to some species life history traits. In this context, our study aims at characterizing how bat communities were affected by ALAN in order to get an insight on the functional changes operating in illuminated environments. With the use of a French citizen science database running the national bat monitoring program “Vigie Chiro” and GIS and satellite data, we analyzed to what extent the level of bat abundance and distribution was affected by ALAN relative to other landscape components at different spatial scales. Additionally, we related these response patterns to species life history traits.

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**Title:** *The Good, the Bad and the Ugly; Instrumental Light Measurement Techniques for Biological Studies*

Published studies on the effects of light on living organisms frequently ignore or misuse light measurement data, due primarily to a lack of understanding of the physics of light and of the instrument techniques used to detect and measure light. Traditionally biologists have used commercially available equipment to quantify the light exposure of test subjects. This use persists despite the fact that most commercial instruments are designed to detect and measure light that is most visible to the human eye (i.e. the CIE curve centred on 550nm) and the lack of data on the visual sensitivity of a species (i.e. increased sensitivity in the uv range <300nm). We have trialled a range of different instrumental techniques over the past 25 years in an effort to precisely and accurately measure light for field based biological research and monitoring programs. In this presentation we will examine the benefits and problems with a number of commercial instruments and rate them against the following criteria;

- Accuracy – is the data biologically meaningful, is it measuring the light the test subject is most sensitive to?
- Precision – are the results reproducible, is the instrument subject to fluctuations due to ambient heat, electrical noise or atmospheric conditions?
- Detection limits – can it measure sky glow?
- Spectral sensitivity range – can it detect light equally from 300nm to 700nm?
- Calibration – can it be calibrated at all, can it be calibrated easily and can some statistical confidence be put around the measurements?
- Size – is it portable?
- Weight – can it be easily carried out to remote sites?
- Ruggedness – can it withstand wind, rain, sand and animal interference?
- Power – can it operate without a hard power supply?
- Target lights – can it target a specific light source?
- Data processing – how easy is it to process the data?
- Modelling - Can the data be used to verify a model?

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**Title :** *Koalas, Kookaburras, Marine Turtles, Iron Ore, Bauxite, Electricity, Trade, Travel, Prosperity, Growth, Legislation, International Agreements and Stars at Night in Australia.*

*“... there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns -- the ones we don't know we don't know.”* Donald H Rumsfeld, 12<sup>th</sup> February, 2002

The understanding of what constitutes life on Earth and the interactions and complexity of the interactions of all biota in food webs and what those relationships are is a challenge, a challenge to understand the whole system and not just the immediate human need. It is an on-going challenge, but of vital importance (particularly longer term) to minimise the loss of species diversity and potentially endanger life on Earth as we know it because of chosen ignorance and selfish indulgence. Mankind can choose to make a difference.

Artificial light has proliferated with the invention and commercialisation of alternating current electricity, new lighting technologies and carbon based fuel motor vehicles. Population increase and a relative decrease in the cost of those resources have both fuelled that proliferation, the expansion and the impact on otherwise dark environments.

Just as ALAN provides a forum for different science disciplines and brings those disciplines together to form a more comprehensive picture and deeper understanding, this paper is about the status quo in Australia, the overall context and the players, indicating the known knowns and the known unknowns (Prokaryotes), however, the unknown unknowns may be even more important (Biosphere II).

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**Title:** *Once upon a time~Thinking Beyond the Telescope and Technology to Understand the Role of Natural Darkness in Developing Community*

As a star lore historian, Mary Stewart Adams works at the local, national, and international level, addressing the consequences of losing natural darkness and demonstrating its effect in the cultural life of humanity.

Through this presentation she will address the role of artificial light at night in placemaking, in the education of the child, and why the storytelling approach to understanding the night sky is as essential as the science and technology approaches.

Our celestial world is like a mighty, living book that has been ‘read’ through every age of humanity and by every culture around the world ~ to inform everything from architecture to agriculture to literature to civic practice and religious observance. When we lose natural darkness and an ability to see the sky at night, we compromise this cultural history, which can result in a fantastic disconnect with the environment, with one another, and with our own history. To this day, we attempt to read this celestial book through the lens of the telescope, the calendar of the farmer, the records of the historian, even the rhythmic lines of the poet. As a storyteller and star lore historian, Mary makes use of all these approaches to support conscientious choices in lighting, as a way to support the healthy cultural imaginations that are needed to inform and infuse community development, education, and scientific research with a quality much needed in today’s world.

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[www.emmetcounty.org](http://www.emmetcounty.org)

<http://interlochenpublicradio.org/topic/northern-night-sky>

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**Title :** *Global Approaches to the Regulation of Light Pollution (For Lighting and Society)*

Research continues to highlight the risks that light pollution poses to human health, safety, ecology, the environment and the loss of the night sky. These issues raise important regulatory questions, namely as to how light pollution is defined in law, without which there can be no effective regulation; the reasons for and against regulation and why and how we should regulate.

Certainly, in the past decade, there has been a surge in regulatory initiatives across the globe. In Europe, there has been regulation in a number of Member States, including Slovenia, the UK, a number of Italian regions, France, Germany and Spain. Outside of Europe there has been regulation in the USA and more recently Korea.

These regulatory mechanisms use a variety of different legal approaches, varying from laws dedicated to light pollution itself (such as in Slovenia); pre-existing laws within which light pollution might be incorporated (such as in the UK); to “soft law” or guidance provided by industry and advisory bodies, (such as the Model Lighting Ordinance in the USA).

This paper will weigh the arguments for and against legal regulation (such as safety and security), compare and contrast the relative strengths and weaknesses of some of these different national approaches. It will also highlight what is considered to be best practice for the effective regulation of light pollution.

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**Title:** *The future of lighting is better if it's dim. How the new technologies of lighting can be used for required and sufficient levels of illumination.*

Humans have created an environment illuminated by non-solar light. The need for illumination has come about from various needs, the resultant levels of illumination have often attempted to parallel the levels achieved during daylight. In recent time Standards and Regulations developed to guide lighting design for particular situations and are seen to be insufficient in prescriptive detail. The recent changes in lighting technologies suggest a need that there is a reassessment of how humans interact with an environment lit by non-daylight methods.

As population centres continue to grow the spread of light at night is not moderated and the only possible trend is for an increase in the use of light at night the issues surrounding light pollution can only be exacerbated. The only solution to reducing potential light pollution aside from legislative control is to develop new ways of using light to achieve current usage applications.

Using a combination of ideas in lighting preferences and technical innovations and identifying specific primary causes of light pollution ideas of supplanting existing lighting applications with new technologies will be examined.

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**Title:** *First estimation of social and economic impacts of dark skies in Montsec.*

Montsec is a calcareous mountain range more than 40 kilometres long in the regions of Catalunya and Aragon in the north-east of the Iberian Peninsula. The Catalanian part includes around 20 municipalities in the counties of Pallars Jussà and La Noguera.

This area showed excellent parameters to develop activities around astronomy and dark skies. For this reason the Government of Catalonia promoted the creation and development of Parc Astronòmic Montsec as a tool to help in the economic development of the region. This development gives the chance to stop the loss of population and the creation and upgrading of new touristic facilities related to dark skies and astronomical activities.

In 2013 more than 1500 km<sup>2</sup> were declared as Starlight Touristic Destination and part of this area became Starlight Reserve thanks to its wonderful parameters of the night sky and the actions taken in the area to preserve it.

Since 2012 the first's analyses of the economic and social impact have been done in the area. For example the results shown by the evaluation process for the development of the 'Pla de Desenvolupament Sostenible del Turisme Montsec 2020' [SomMontsec 2012] as strategic plan for tourism in the area. Recently a new study [CEL 2014] has been done studying the visitors of Parc Astronòmic Montsec and how they participate in the local economy and in alternative activities in Montsec area.

These preliminary studies give us important results in the improvement of Montsec area. For example the number of accommodation facilities has been doubled in the last decade, the stop of the loss of population in the area or the estimation of 750.000 Euros of economic activity generated in the area by the visitors of Parc Astronòmic Montsec.

All these preliminary results point in the idea of the important contribution to development of a rural area created by the dark sky protection and astronomical activities.

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**Title:** *The control of the effects of the artificial light at night - doing its part*

Quebec has a lot of passionate people trying to apply the principles of the control of the artificial light at night.

IDA Quebec, the Quebec chapter of the International Dark-Sky Association, a non-profit organization, it's one of those working hard for the future generations and their right to see the starry sky during the night.

This effort is not always easy and is asking a lot of ideas, time and money.

We are proposing you an incursion in the life of our organization to meet the paradoxes we are living and the solutions we are putting in place: popularization, education, communication, normalization, promotion.

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**Theme:** "Biology & Ecology"

**Title:** *Findings, Challenges, and Solutions: Restoring the Night Sky Gulf Coast Sea Turtle Restoration Project*

In an effort to offset impacts to sea turtle nesting habitats that occurred during the Deepwater Horizon oil spill and associated cleanup activities, the Florida Department of Environmental Protection and the Florida Fish and Wildlife Conservation Commission contracted with the International Dark-Sky Association (IDA) for beach lighting surveys. Under this contract IDA conducted site assessments in twenty-five conservation lands along the sandy Gulf of Mexico shoreline to identify exterior lights visible from sea turtle nesting beaches. Data collected during the assessments were used to develop lighting retrofit recommendations for local governments, private homeowners and property managers to reduce potential artificial lighting effects. Recommendations called for the replacement of existing problematic exterior lights with fully shielded, narrow-spectrum long wavelength fixtures as part of a coordinated light management program to reduce lighting impacts to threatened loggerhead sea turtles on Florida's Panhandle beaches.

Results of IDA's 2012 lighting surveys will be presented. In addition to surveying the lighting in and around the program's conservation lands, IDA made night-sky brightness measurements using Unihedron Sky Quality Meters and using an all-sky method. The darkest skies measured in the pre-retrofit surveys were found in the eastern portions of the survey region with values are dark enough to qualify for IDA's International Dark Sky Places program, which awards dark sky status to parks and reserves around the world. Other parts of the survey documented regions with significant levels of light pollution. Night sky measurements will be repeated, likely in 2015, after the problem lighting that was identified has been replaced.

Some areas of the survey region exhibited sea turtle friendly lighting in the vicinity of nesting beaches, yet there are still many areas that need improvement. In conjunction with the lighting surveys IDA made recommended lighting solutions designed minimize impacts to sea turtle nesting areas. In some cases IDA worked along with lighting industry leaders to custom design new lighting products to meet lighting retrofit recommendations for the program. The solutions adhere to the highest standards in terms of light distribution, spectrum, cost-effectiveness, and durability.

Turtle-friendly light fixtures are designed to keep light where it is needed—pointed downward. And turtle-friendly light sources limit the spectrum of light emitted to minimize the impact on turtles. When used properly, these lights provide proper illumination for human safety without negatively impacting sea turtle nesting or hatchlings' ability to find the ocean.

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**Title:** *Aiming High to Raise Awareness of ALAN in Protected Areas*

The reduction of light pollution is still a topic with a small following. However, there have been two meetings in 2014 that demonstrate its profile is increasing. We participated in two major international meetings at which the arguments for light pollution abatement policies were presented and defended. We present the outcomes from these two international meetings.

An August meeting in Arizona brought together light fixture manufacturers, municipalities, NGOs, governments and researchers. The initial consensus was for the need for more research into technologies that would reduce LP. However when compliant luminaires were demonstrated the consensus shifted towards the need to implement existing technologies. The need for supportive government policies and public education remain as challenges.

The IUCN hosted 6,000 delegates from around the world during the World Park Congress in Sydney Australia. Most Park Managers, NGOs and conservation organizations were not familiar with the impact that artificial light at night has on the environment. We actively promoted the development of policies to address light pollution in protected areas, and presented a rational guideline for outdoor lighting as a basis for implementing this policy.

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**Title:** *Community and ecosystem responses to artificial night lighting across aquatic-terrestrial boundaries*

Artificial night lighting is predicted to increase in intensity and extent as the global population continues to grow and as electric lighting expands into previously unlit communities of the economically-developing world. Consequently, most remaining “unlit” areas of the world are unlikely to persist. Aquatic systems can be particularly vulnerable to the impacts of artificial night lighting in part because they are often located in close proximity to human settlements. Evidence increasingly suggests that artificial night lighting will have severe consequences across multiple levels of ecological organization (i.e., species, populations, communities, and ecosystems), although community and ecosystem level effects remain largely unresolved. We investigated the impact of artificial night lighting on food webs and ecosystem function in stream, wetland, and riparian ecosystems of the Columbus Metropolitan Area of Ohio, USA using a combination of observational and experimental approaches. Increased artificial night lighting was associated with decreased emergent aquatic insect richness and mean body size as well as reductions in the density of riparian spiders of the family Tetragnathidae, which can be highly reliant on emergent insect prey subsidies. Elevated lighting was also related to increased mean body size of nearshore terrestrial arthropods, delayed leaf senescence and abscission in riparian trees, and trophic shifts in both aquatic and terrestrial invertebrate food-web members. An ongoing laboratory study is evaluating lighting impacts on algal productivity. Collectively, our results provide evidence that artificial night lighting can act as an environmental disturbance that quantitatively alters food-web structure and energetic fluxes (i.e., carbon, nutritional prey subsidies) across aquatic-terrestrial ecosystem boundaries.

## INVITED TALK

### Dr Will Straw



**Director,** McGill Institute for the Study of Canada, McGill University, Québec, Canada

His research interests is night-time in cities in relation to the regulation of entertainment and other night-time behaviours, historical patterns of night-time culture and new initiatives being taken by cities to transform the night. This is part of a broader interest in "cultural scenes" and the manner in which they occupy cities.

He is Director of the McGill Institute for the Study of Canada and Professor within the Department of Art History and Communications Studies at McGill University in Montreal. He is the author of *Cyanide and Sin: Visualizing Crime in 1950s America*, and co-editor of several books, including *Circulation and the City: Essays on Urban Culture et Formes urbaines: circulation, stockage et transmission de l'expression culturelle à Montréal*.

For more information : <http://willstraw.com/> and <http://theurbannight.com/>

#### ***Title : Film noir after black-and-white***

My paper will look at the transition from black and white to colour filmmaking, which reached a certain intensity in the 1950s, and the ways in which that transition affected representations of the night. In particular, I will look at a variety of so-called *films noirs* of the 1950s, in which lighting design sought to perpetuate the aesthetics of a menacing night-time space – an aesthetics developed in black-and-white filmmaking – in films that now were made in colour as a result of changing market demands. From the 1950s through the 1970s, directors, cinematographers and lighting designers have experimented with a variety of lighting strategies intended to keep alive the black—and-white aesthetic of *film noir* in an era in which audiences expect colour. My presentation will be accompanied by a number of film examples.

Two examples illustrate this point. The first, IDA's well-established Dark Sky Places Program, provides rich insight into why alliances and community building have been essential to the overwhelming success of this international initiative. The second, which is nascent and only at the earliest stages of development, is an IDA Night Sky Land Stewardship Program that aligns our mission with that of the land trust sector. Pioneering a new program expanding the list of natural assets that land trusts work to protect in perpetuity would not only dramatically increase the reach of IDA's mission, but would build new, robust, and highly leveraged partnerships within the non-profit sector.

Looking back – by learning from our earlier experiences, and looking forward – by anticipating future challenges, will sharpen and inform our thinking so that together... we can change the world.

## INVITED TALK

Mrs. Noamie Miller



**Designer/Senior Scientist, Pacific Northwest National Laboratory, WA, USA**

Her research interests are lighting quality, the aging eye, health effects of light, dark skies, sustainability and energy efficiency. In 2013, she authored a DOE GATEWAY report, “*Pedestrian Friendly Outdoor Lighting*”. Together with co-authors Terry McGowan and Rita Koltai, this paper examines visual comfort, desired light levels, and light color issues for two pedestrian-intensive campuses.

The surprising results show that pedestrian needs and preferences may be entirely different from traditional roadway lighting goals. She uses her decades of experience in architectural lighting design in Upstate New York and San Francisco to educate clients, customers, and practitioners and help nudge the SSL industry toward better, more practical solutions. By bridging the gap between technology and application, she can promote the wise use of LEDs, working with industry to overcome the hurdles and celebrate the opportunities. She is a Fellow of the IESNA and Fellow of the IALD.

For more information: [http://tpd.pnnl.gov/staff/staff\\_info.asp?staff\\_num=1990](http://tpd.pnnl.gov/staff/staff_info.asp?staff_num=1990)

### ***Title : Pedestrian-Friendly Nighttime Lighting***

Not all outdoor lighting is for vehicles, nor intended for visibility alone. This talk will present ideas for making campuses and walkways more inviting at night, and less intrusive for the night sky. Two case studies will address controlling glare, as well as color preferences and light distribution.

#### Learning objectives

- See what pedestrian-friendly lighting looks like. What kinds of communities and space types should consider pedestrian-friendly outdoor lighting?
- Understand the basic principles of glare control. How much does glare control affect other performance metrics?
- Understand why traditional roadway lighting metrics may not apply to pedestrians. Are there less numerical “metrics” that can be used instead?

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**Title:** *The Rewards and Challenges of Protecting International Dark Sky Places*

Since 2001 the International Dark-Sky Association's International Dark Sky Places designation program has recognized dozens of Communities, Parks and Reserves around the world. Awards are made on the basis of sustained local efforts to improve night sky quality through a combination of public policy and education and public outreach. The program has achieved notable successes, elevating the profile of dark skies in the fields of resource conservation and land management while becoming the most publicly visible example of IDA's commitment to its mission to preserve and protect the nighttime environment. Dark Sky Places engage the public directly, and the choices made now by designated locations have implications for public perception of dark skies as a cultural good in years to come. Despite continuing efforts at Dark Sky Places after receipt of IDA designation, the future presents a number of potential obstacles to long-term site protection. I will discuss some of the relevant issues, including external threats, multiple land uses, ongoing monitoring of night sky quality, the need for legal safeguards, emerging lighting technologies, and the question of enduring public access.

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Please note that two of these authors will present the seminar

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**Title:** *Assessing than Mitigating (Skyglow Measurements to Lighting Ordinances)*

### *Introduction*

The most effective plan starts with understanding the severity of problem. Skyglow dome measurements provide base case data to determine the magnitude and the location of significant light pollution sources. Base case data informs the development of community wide lighting ordinance that will reduce the skyglow over time.

### *Assessing Existing Skyglow*

A series of measurements are taken to assess current level of skyglow. These measurements are used to establish a baseline, quantifying the current relative severity of light pollution.

### *Mitigating with a Lighting Ordinance*

To mitigate the influence of future development and to provide a method to curb the negative impact of existing installations on the nighttime environment, lighting ordinances provide a vehicle for establishing appropriate and enforceable requirements that benefit the greater good.

An effective lighting ordinance must provide mechanisms to curb wasted light, reduce light pollution, restrict glare, and prevent light trespass in an enforceable manner that preserves the night sky. An effective lighting ordinance will achieve this while accommodating industry-established lighting needs. Additionally, it will respond to the local ambient conditions, satisfying expectations while curbing excess.

A lighting ordinance must address each component of light pollution directly. Specific limits should be set on the total amount of light allowed on a specific development or for a specific application to reduce wasted light and minimize reflected light to the maximum extent possible. Light trespass should be limited, either in the form of luminaire-specific distribution limits or in the form of boundary conditions. Uplight should be eliminated in all but limited applications to mitigate impact on overall sky glow. Glare should be controlled in the form of luminaire-specific distribution limits and shielding requirements. Correlated color temperature (CCT, which is the whiteness of the light) limits should be set to restrict the blue-light emissions, which have been shown to have deleterious effects on humans and the environment at night and increase perceptions of glare. Finally, recommendations and/or requirements for lighting controls should be included to reduce or extinguish lighting when not required.

In addition to these functional characteristics, the requirements of a lighting ordinance must be enforceable, with guidance for applying requirements, planning and permitting submittal requirements, appropriate exemptions, and field-verifiable metrics. Because of the need for an enforceable structure, it is typically recommended that a model or pattern lighting ordinance be employed as the fundamental guiding structure. Model or pattern lighting ordinances have been developed through multiple organizations and mechanisms, some developed directly with the technical bodies responsible for developing industry-standard lighting recommendations. Typically, they are developed with input from planners and code officials to ensure that the language is readily adoptable.



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### **Title: Using Uniformity to Optimize Parking Lot Lighting**

Optimizing outdoor lighting applications requires meeting multiple design criteria while minimizing unintended consequences such as light pollution, high energy use, or high costs. Building on Rea and Bullough's original concept of application efficacy, the luminaire system application efficacy (LSAE) metric was developed to quantify the effectiveness of a luminaire or whole installation at meeting design criteria. By using LSAE as a performance metric, manufacturers and applications designers can find lighting solutions that provide the required photometric requirements with minimum energy use and wasted light. Further, LSAE can be used in different applications simply by adapting the target criteria in each application. Recommended practice for outdoor lighting applications are based mostly on photopic illuminance and almost always include some measure of uniformity, however, little is known about the origin of those uniformity recommendations or whether uniformity can be traded off with illuminance. For parking lot lighting, the LSAE metric was originally based on the recommendations found in IES RP-20-98 with the understanding that further research was needed.

This presentation will summarize a human factors field study conducted to understand the benefits of improved illuminance uniformity in parking lots in terms of user perception and acceptability, as well as energy use. The results from the study showed that more uniform distributions are favorably perceived by people in terms of goodness of illumination, ability to see around and at a distance, and perception of safety, all of this at a much lower average horizontal illuminance. Thus, improving uniformity alone can translate into lower energy use and potential for less glare and light pollution. The presentation will include a discussion of how these results were used to modify the LSAE metric and how designers can use LSAE as a tool in their quest to achieve applications that are visually, energy, and environmentally responsive.

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**Title:** *Protected places and the night sky, a match made in heaven*

In order to protect ecological and cultural integrity, the managers of protected sites and areas (PAs), should, and increasingly do, strive to reduce light pollution. Dark nights and clear skies, coupled with night walks and star parties, enable visitors to experience and learn about nocturnal wildlife, ecology of the night, bioluminescence, aurorae and the wonders of the universe. They also come to better understand and respect the value of the night sky to traditional societies, historic cultures and spirituality. For PA managers, investment in light pollution prevention is a low cost initiative that demonstrates environmental stewardship, provides opportunities for science and learning, reduces operating costs and can lead to increased visitor numbers.

Dark sky advocates should embrace the opportunities that PAs can bring to the campaign to reduce light pollution. Parks and historic sites host large numbers of people interested in an unpolluted nature, authentic historic sites and different cultures. Visitors are receptive to night sky interpretation, even in daytime. They become encouraged to return at night and to grasp the importance of the night sky to a whole, healthy planet. PAs can provide the venue and audiences for talks, community outreach, citizen science, static and interactive displays and star parties that bring life to the combination of wild nature and clear skies, and archaeoastronomy at cultural heritage sites. However, the active participation of night sky enthusiasts to is necessary to make this happen.

A “dark sky park” is a protected natural or cultural area or site that 1) protects natural darkness through appropriate outdoor lighting, 2) allows public access for night sky programmes, and 3) encourages light pollution abatement in the surrounding area. It may also facilitate research, monitoring and interpretation of astronomy and night ecology. The first such place was Michigan's Lake Hudson Dark Sky Preserve established in 1993. In 1999, Ontario's Torrance Barrens Conservation and Dark Sky Reserve was the first dark sky park recognized by an astronomy society. In 2007 the International Dark-Sky Association began to recognize dark sky parks, reserves and communities, starting with Natural Bridges National Monument International Dark Sky Park, Utah. Astronomy societies, governments and universities also recognize dark sky places. By December 2014 there were sixty-one such places in fourteen countries. There are also ten dark sky communities.

The IUCN uses a six class system to compare protected natural areas regardless of local naming systems. The IUCN Dark Skies Advisory Group has developed a similar system to help compare dark sky places with varied names or conflicting definitions, such as park, reserve, preserve, starlight reserve, star park, starry-sky park and community. The DSAG system is: 1) Astronomy Observatory Site; 2) Park, with three sub-classes; 3) Heritage Site; 4) Outreach Site, with two sub-classes; 5) Reserve; and 6) Community. Definitions and the world list of dark sky parks can be accessed at < [www.dsag.darkskyparks.org](http://www.dsag.darkskyparks.org) >.

As the number of dark sky places grows, there is a burgeoning set of protected places where natural and cultural heritage advocates collaborate with night sky enthusiasts to reach the critical mass of citizens who will influence decision-makers to curb light pollution.

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**Title:** *Cities at night: a citizen science program to make a color map of the world.*

Astronauts have been taking images of the Earth at night since 2003. However, only a small fraction of these have been used for outreach and even fewer have been used for research. The "Cities at Night" project was created to enable use of the huge archive of such images currently available. Since July 2014, more than 130,000 images have been classified. Among them, we have found more than 30,000 night images of cities worldwide. More than 2,300 images have been properly identified, and more than 500 have been georeferenced. This new atlas of the Earth at night, despite being still in construction, is a potential source of data for numerous studies of lighting with a social impact. It also demonstrates the power of citizen science. In this contribution, early maps and preliminary examples of data-products will be presented.

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**Title:** *Lighting Conflicts: High Noon Ahead?*

Artificial outdoor illumination – from street lights to brightly lit buildings and billboards – has become a commonplace feature in many regions of the world. As such, it is often taken for granted and has been met with little regard by the public, policy and research for a number of decades: Lighting was rarely an object of debate or politics – it was simply ‘there’ and generally left to experts.

However, while lighting levels overall continue to rise, negative impacts of artificial light are gaining recognition. Familiar night-time atmospheres are changing as streetlights are replaced at a large scale, introducing new qualities and intensities of lighting; many cities are dimming or switching off lights to cut costs while others are staging lighting festivals to attract visitors; policies are beginning to curb long-standing liberties in the planning, usage and availability of light; and yet, new technologies allow for ever-brighter animated signs and illuminations at minimal costs. Such developments are likely leading to an increase in and a diversification of conflicts relating to light, all the more as they follow a several-decade long period of relative stability.

This contribution will present a first, theoretically informed approach for how lighting conflicts could be classified and contrast this with the results of an initial analysis of media reports. As lighting conflicts prove to currently be easier to classify than to identify, an alternative approach to understanding lighting conflicts will then be outlined: An exploration of analogies between artificial light and sound/noise – another sensory stimulus that has already undergone developments similar to those encountered by lighting today.

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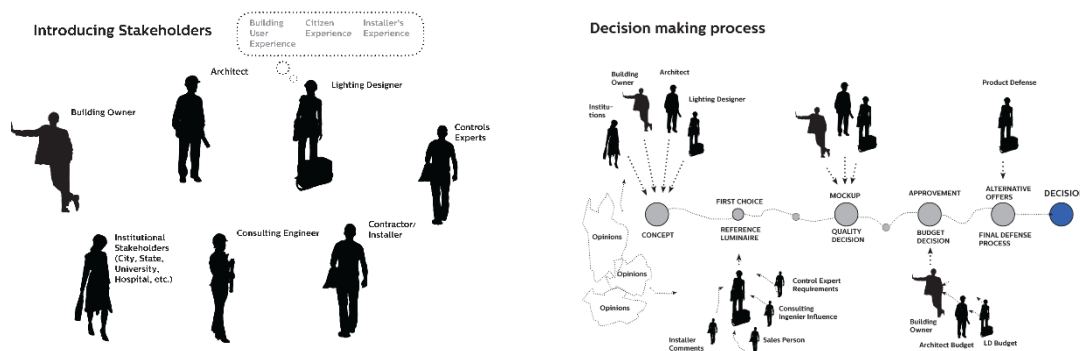
**Title:** *From concept to product – who decides on fixtures?*

Research about environmental consequences related to lighting has increased; at the same time new indoor and outdoor luminaires on the market address topics that are gaining public awareness, e.g. “dark-sky friendly fixtures”. For both manufacturers and researchers, it is interesting how such fixtures are actually chosen: from early influences through the final installation of a product. What is the intricate decision-making process in between?

This presentation will demonstrate how lighting designers choose the luminaires for a project together with building owners, institutional stakeholders, architects and other stakeholders using a real-world case study. The decision-making process is analyzed in detail and important milestones are highlighted graphically.

The actual project that is shown is the illumination of the cultural brewery Berlin, where a new lighting and signage project was executed to keep the cultural venue attractive and react to increased visitor numbers during the night. Historic preservation issues had to be considered as well as event flexibility, security issues and the atmosphere of the space. Studio Dinnebier, Berlin was responsible for the concept, detail design and execution as well as the hands-on work on site for aiming the luminaires, including live phone talks with neighbors while projecting light.

With this insight into the building industry, we will see that there are several stakeholders that play an important role for the illumination of a building. Several decision-making steps like concept, reference luminaire, mock-up, planning and cost issues lead to the lighting products used. With this knowledge, we can foster a discussion about how research might influence the way buildings are lit and what new research questions might evolve from an enhanced understanding of this process.



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**Title:** *Improvement of LED performance by Increasing Light Extraction Efficiency: An example of how to stimulate college students to research in engineering through advanced micro-nano-fabrication improvements*

Street lighting using Light Emitting Diodes (LEDs) has many advantages compared to traditional lighting: low energy consumption, ecofriendly (e.g. no mercury), long lifetime, etc. The performance of the overall module depends on the performance of single LEDs. The LED mostly used for street light are Gallium Nitride (GaN) based, and still there are some issues for this kind of devices. One problem is the light extraction efficiency (LEE); indeed, due to reflection at the semi-conductor / air interface, only few percent of the light emitted from the active region of the LED is coming out and the other part is trapped in the semiconductor; for planar LEDs (without any specific treatment) the LEE is about 3.7%. We have developed bio-inspired 3D surface structuration on the top of LEDs to avoid the reflection and increase the overall light emission. The 3D structure proposed are bio-inspired from fireflies and optimized by simulation with a genetic algorithm (international collaboration with Belgium colleagues expert in). The first generation of bio-inspired LEDs was fabricated and they exhibited a LEE about 5.7% which is an enhancement of about 56% of the light output compare to a conventional planar LED. We are currently working on the second generation of bio-inspired LEDs and we expect to have LEDs with a LEE about 11%. Further to this optimization, we are also working on strategies to optimize LED spectra with respect to their environment. In parallel with this research work we are collaborating with Cégep de Sherbrooke to expose students to the whole improvement scenario behind LED lighting technology from technological challenges to better environment with the objective encourage them to pursue their education in science and engineering.

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**Title:** *Achievements and consequences of light pollution legislation in Slovenia*

A Decree on Limiting Values of Light Pollution was adopted in Slovenia in 2007. This was and still is one of the best if not the best ordinance in the world. At first it was a shock for lighting engineers and lighting industry, but all suppliers have adopted very quickly on ban of any emission over horizontal. Achievements of outdoor illumination in Slovenia will presented including light pollution monitoring and economy from a view of taxpayers and suppliers.

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**Title:** *Modelling of light pollution over Poland using Berry's model with high resolution data*

In order to investigate the level of light pollution in Lower Silesia, Poland, the observational data were collected and used to create a map of night sky brightness. Data were collected using two methods: using Sky Quality Meter and using photographic method. The latter one requires only an ordinary camera, so it is perfect for amateurs involved in data collection. Results obtained with both methods are presented. Collected data were used to recalibrate the model of light pollution which was originally created by Berry for Southern Ontario (Light Pollution in Southern Ontario, JARSC, vol. 70, No. 3, 1976). Recalibrated model was also improved and used to create the map of night sky brightness (50 meter resolution). In the original model Berry calculated light pollution caused by cities regarded as single points. Significant improvement was to treat each cell in the raster map of the region as a 'city' in Berry's model. Population of each cell was estimated using dasymetric modelling. This improvement was crucial to obtain detail structures of sky brightness, but it did not complicate calculations. The GRASS GIS software was used in the analysis. The results nicely fit observational data.



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**Title:** *Characterizing Night Sky Brightness In and Around Tucson and Nearby Observatory Mountaintops*

To characterize the night sky brightness in and around Tucson, Arizona, USA, measurements have been taken since mid-2012 with Unihedron's Sky Quality Meters (SQM-LU-DL+H devices) stationed in 8 locations: at the National Optical Astronomy Observatory (NOAO) near the center of Tucson, 13 to 14.5 km N, E, S and W of NOAO and on 3 nearby observatory mountaintops. For the first year of data, significant differences between city and mountaintop locations could be seen after data reduction (as much as 3.5 mag/sq arcsec). Brighter locations appeared to darken as the night progressed (as much as 1 mag/sq arcsec). Seasonal variations were seen at most locations, more pronounced for brighter areas (as much as 2 mag/sq arcsec). Trends will be reported on the more recent data.

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**Title:** *Ecologically relevant amounts of artificial light at night can alter tadpole growth, development, and nocturnal activity.*

Most species of amphibians, including frogs, are primarily nocturnal and are at great risk of exposure to artificial night lighting in areas where sky glow and glare from anthropogenic lighting enter habitats where amphibians live and breed. We investigated the effect of artificial light at night (ALAN) on the growth, development, and nocturnal activity of tadpoles. In particular, we were interested in how very small, ecologically relevant amounts of light pollution might affect tadpoles reared under those conditions. Under a 12L:12D photoperiod in two separate experiments, we exposed developing African Clawed Frog (*Xenopus laevis*) larvae to diurnal illuminations of 100 lx (equivalent to dim room lighting) and one of four different nocturnal illuminations: 0.0001 lx (normal, dark nocturnal illumination), 0.01 lx (moderate amount of light pollution equivalent to full moonlight), 1 lx (substantial light pollution equivalent to dusk/dawn), or 100 lx (extreme light pollution; same as day lighting in our design to abolish photoperiod entirely). We then compared growth (change in body size), developmental stage, and nocturnal activity (distance moved) of larvae reared in the four treatments. Tadpoles grew faster but developed more slowly in all of the artificial night lighting treatments relative to tadpoles in the dark (0.0001 lx) control treatment. Nocturnal activity was significantly reduced in animals in the 1 lx and 100 lx lighting treatments but activity in the 0.01 lx treatment appeared to be intermediate between the lighter treatments (1 lx, 100 lx) and the dark control (0.0001 lx). Our results demonstrate that even very small and ecologically relevant amounts of light pollution (equivalent to moonlight) chronically entering amphibian habitats can affect frog larval growth and development resulting in large, under-developed larvae. Additionally, our data demonstrate that small, ecologically relevant amounts of artificial light at night suppress nocturnal swimming activity in tadpoles. Such changes to growth, development, and nocturnal activity may have serious ecological impacts on frogs exposed to such lighting conditions.

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**Title:** *The behavior of aquatic larvae and terrestrial juveniles of the Spotted Salamander (Ambystoma maculatum) is influenced by artificial light at night*

Artificial light at night (ALAN) is increasingly common and can impact the behavior of nocturnally-active species. Many species of amphibians, including salamanders, are primarily active at night and have complex life cycles that include an aquatic larval and adult terrestrial stage. We examined the effect of ALAN at ecologically-relevant levels (e.g. comparable to a moderate level of light pollution) on the activity of aquatic larvae and newly metamorphosed, terrestrial juveniles of spotted salamanders, *Ambystoma maculatum*. We hypothesized that the activity of both larvae and juveniles would be impacted by ALAN. To test this hypothesis, larvae were collected from a local pond and kept in an environmental chamber under controlled conditions: 16L (100 lx):8D ( $<10^{-5}$  lx) photoperiod at 20 C until testing. Each larva was randomly assigned to one of three nocturnal light treatments on a 16L:8D photoperiod: 0.0001 lx (control, natural dark illumination); 0.01 lx (moderate amount of light pollution); and 1 lx (substantial light pollution); diurnal illumination was 100 lx in all treatments. Larvae were habituated to the lighting treatments for 6d before they were placed into a testing arena (test chamber with a central cover object). After 24 h for habituation to the test arena, we recorded the behavior of larvae (distance moved and time spent in EDGE, an escape behavior) from 2 h before dark to 1 h after lights on using infrared cameras. After metamorphosis, terrestrial juveniles were again tested in the same experimental lighting treatments. After 7 d, we recorded the activity of juveniles in test chambers with cover objects for 24 h. Larvae in the 0.01 and 1 lx treatments moved significantly less (distance) and exhibited more escape behavior than larvae in the control, dark treatment at certain times during the night. Juveniles did not move as much as larvae, so we monitored the time to emergence from under cover objects and time spent outside cover objects when exposed to ALAN compared to juveniles in the dark controls; juveniles exposed to ALAN were active before dark, whereas those in the dark treatment emerged after dark or remained under cover during the entire night. These results suggest that ALAN alters the nocturnal behavior of these salamanders. Larvae and juveniles are under heavy predation pressure, such that increased activity by both larvae and adults during diurnal periods may increase risk of predation and impact survival.

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**Title:** *Implementing Clouds into the Night Sky Radiance Model Illumina*

In this paper we describe the implementation of a simple cloud scheme into the night sky artificial radiance model Illumina (Aubé 2005) to simulate overcast conditions with a variety of cloud types and base height. We are showing the first results obtained with this new scheme in comparison with the clear sky case presented in Aubé 2014.

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**Theme:** "Society"

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**Title:** *Sydney Outdoor Lighting Society*

The Sydney Outdoor Lighting Improvement Society was formed in 1991 to work with people with issues concerning excessive lighting to approach and lobby local councils, work as an independent adviser on lighting issues, to form a focal point for amateur astronomers concerned about outdoor lighting.

After a period of intensive work with Sydney Observatory and Sydney City Council during the construction and development phase of the Sydney Olympics in 2000 SOLIS had formed a set of policies to regularly submit advice on Development Applications to Sydney City Council and work with residents of local councils to lobby at Council for restrictions on lighting developments.

SOLIS has also written submissions for several development and planning controls at council level and attended workshops on matters where lighting issues may have an impact.

SOLIS is seeking to expand its influence concerning the introduction of new lighting technologies to street lighting and city planning.

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**Title: *Strategies for Mitigating Light Pollution from Oil and Gas Field Lighting***

Upstream oil and gas infrastructure may be readily compared to industrial facilities placed in rural and wilderness settings. Because of these situations, the light pollution associated with oil and gas extraction had generally been ignored as few people were impacted by them and because the impact of artificial light at night had not been fully recognised. With more intensive development associated with heavy oil and coalbed methane as well as such work extending into areas with other users, negative light pollution impacts are more obvious. Australia's Siding Spring Observatory's dark skies may be under threat from coal bed methane development due to the common practice of flaring, and there are countless other examples both onshore and off where oil company light pollution has created problems.

Directive 60, *Upstream Petroleum Industry Flaring, Incinerating, and Venting* of the Energy Resources Conservation Board (ERCB) of the Canadian Province of Alberta (which also adopted by the adjacent provinces of British Columbia and Saskatchewan) tightly controls how and when natural gas may be flared. In 2013, industry captured 95.3% of the gas it produces as an unwanted byproduct primarily from *in situ* oil sands and crude oil operations. This value is higher than the 92% in the benchmark year of 1996 and 94.2% in 2012. Vented methane is a powerful greenhouse gas and though burning it to form CO<sub>2</sub> reduces its impact on that front, the flaring process adds to light pollution. Though sometimes maligned in the popular press, the Canadian oil and gas industry operates under some of the most stringent regulations around. These or similar regulations, if enacted near Siding Spring, or North Dakota, would be a large step in the protection of the naturally dark night sky.

Our group has lobbied the Alberta Energy Resources Conservation Board to take further steps in controlling oil and gas outdoor lighting through proposals that mirror the ERCB's existing regulations on noise (Alberta Energy and Utilities Board, 2007). Additional regulations or guidelines are needed as has been shown by the role that artificial light played in nocturnal mass mortality events of waterfowl in oil sands tailings ponds (St. Clair et al. 2011) and by the fact that a number of oil companies are now using outdoor light in a restricted and responsible manner in their oil field operations (e.g. Haverhals 2009).

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**Title :** *A Satellite Based Intrusive Light Model*

We produced a model of intrusive light for Sherbrooke with a set of satellite images. We used VIIRS-DNB in combination with MODIS reflectance imagery and with an averaged characterization of light fixtures for different city areas. The photometric properties of light fixtures were estimated by random sampling of a few streets per area with the help of Google Streetview. Actually, it is possible to recognize the light fixtures models with Google Streetview and to count them to establish the relevant mix of their photometry functions for each area. We are determining the amount of light emitted in 3 main directions: 1-the upward light reaching the VIIRS sensor; 2- the downward light reflected by the ground; 3-the light reaching a typical bedroom windows (with a coarse estimate of distance and height of windows relative to the lamp). This vector layer was converted to raster format to produce an estimated map of the intrusive light that enters a typical bedroom window. The spatial resolution of the map is 750m x 750m. The calculation of the intrusive light map is made with the raster calculator capabilities of QGIS software. To evaluate the accuracy the intrusive light map, we acquired illumination data in a number of bedrooms in different part of the city. The comparison between the modeled map and the in-situ measurements is presented in this paper.

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**Title:** *An Experimental Plate-form to study the impact of Artificial Light on flora*

Artificial light is known to have some significant effects on plants. In greenhouses, plants usually grow up under artificial light intensively. This industry is usually concerned about the weight gain of the plants in order to have the biggest crops. It becomes important to show how artificial light can affect the plants quality and quantity. Our research hypothesis is that the spectral power distribution is a major factor in the determination of richness of the plants content (aromatic compounds, vitamins etc.)

To test this hypothesis, we designed a dedicated plate-form comprising two growth tents, each one lighted with two very different lamps. The first is an HPS lamp, commonly used by the greenhouses industry, and the second is a custom lamp designed by our research group. The spectral distribution of our innovative lamp can be actively transformed with some constraints. Among many possibilities, it permits to mimic many natural lights like a sunny day, a cloudy day, a sunset, the moon light, etc. The plate-form also include a custom automation system to control the environment variables (humidity, temperature) from a open source arduino microcontroller.

As first experimentation with this plate-form, we planted lettuce, wheat and basil into Biotop's pots modules. We followed the development of the plants by measuring their growth, their leaf quantity, their coloration and other biometric characteristics. We also measured some biochemical parameters (amount of carotenoids, chlorophyll and phenolic compounds). In this paper, we will show the preliminary results of this experimentation.







## Sherbrooke Cycling Trails

Discover our city through the cycling trails! Grandes-Fourches network cycling map is available on Tourist Information booth in the lobby of Grand Times Hotel



Take the opportunity to bike on rue du Cégep and discover its road lighting with the new optical filter light for nocturnal integrity protection



Take the opportunity to bike on Boulevard Lavigerie and discover its road lighting with the new amber light for dark sky protection



Grand Times Hotel

destination  
SHERBROOKE .com

The BlonX bikes will be available for free at the Grand Hotel Times front desk.

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*Fermons nos lumières pour allumer notre ciel!*

*Turn off the lights to turn on the sky!*

*-Léonie 11 ans*