Appendix D - Light Pollution References and Definitions, Rev 12vu

Prepared by Jim Ronback. < Jim_Ronback@dccnet.com > Additions are welcome. Links are valid as of 22 March 2007. Please advise of any broken links.

This list of references below is continuously evolving. It is aided by monitoring some Yahoo groups related to light pollution issues. In the PDF version of this document, the underlined links are clickable. In the Word version you need to hold down the CTRL key:

http://groups.yahoo.com/group/DarkSky-list/
http://groups.yahoo.com/group/CFDS/
http://groups.yahoo.com/group/OutdoorLighting-Forum/

http://www.celfosc.org/mag6/ European list on Light Pollution
http://unihedron.com/projects/darksky/ - a list on their Sky Quality Meter

I measured the effects of good and bad lighting around Delta, BC using a photometer.

One useful and relatively inexpensive photometer to use is the Sky Quality meter. It can be attached to your binoculars to easily point and take measurements of disturbing light sources at night. It reads the light input from a cone whose 1/2 angle is about 35 degrees. See page 2 of:

http://unihedron.com/projects/darksky/sqmreport_v1p4.pdf?PHPSESSID=74c761fac91850656ee4cedb5980275a

The following new book is highly recommended:
"**Ecological Consequences of Artificial Night Lighting**", edited by Catherine Rich and Travis Longcore, Published by Island Press, 2006, 458pp, ISBN 1-55963-129-5, $29.95 USD. It is a gold mine of information on the effects of artificial night lighting on fauna and flora.

A review and the bibliography of the above book appear here:

http://www.urbanwildlands.org/Resources/LongcoreRich2004.pdf

http://www.urbanwildlands.org/nightlightbiblio.html

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http://www.gr.nl/pdf.php?ID=321&p=1 English
http://www.gezondheidsraad.nl/pdf.php?ID=182 Dutch

Impact of outdoor lighting on man and nature

http://en.wikipedia.org/wiki/Light_pollution
Excellent encyclopedia article with definitions plus links

http://dmoz.org/Society/Issues/Environment/Light_Pollution/
Open Directory listings on Light Pollution

http://directory.google.com/Top/Society/Issues/Environment/Light_Pollution/
A Google listing on light pollution

http://www.amazon.com/gp/richpub/listmania/fullview/RT43NNE4I88XZ/103-0184075-6903849
http://tinyurl.com/7md7s List of books on Light Pollution

http://www.communities.gov.uk/index.asp?id=1144844
Towards Better Practice - Secs. 9-10, Lighting Issues - UK Office of the Deputy Prime Minister

http://www.streetlightiq.com/filez/pg_lsi_project.pdf
Street Light Intelligence in Victoria, BC

http://www.nmheritage.org/files/nmhpa_nwsltr_winter_05_web_version.pdf
New Mexico - PROTECTING DARK NIGHT SKIES

http://www.muskokaheritage.org/ecology-night/recommendations.asp
Recommendations from the conference

http://www.muskokaheritage.org/ecology-night/summaries4.asp
DARK SKY COMPLIANCE THROUGH VOLUNTARY AND REGULATORY MEANS

http://www.environment-agency.gov.uk/yourenv/eff/1190084/pollution/152227/
Environmental Facts and Figures on Light Pollution

http://www.shopatsky.com/index.asp?PageAction=VIEWCATS&Category=97
A book for children - There Once Was a Sky Full of Stars

DARK SKY PRESERVES

http://www.muskokaheritage.org/ecology-night/media/brian-whitehead.pdf
Dark Sky Initiatives In Muskoka

http://www.muskokaheritage.org/ecology-night/media/david-welch.pdf
Parks Canada and Light Pollution

http://www.muskokaheritage.org/ecology-night/media/dorothy-shaver.pdf
Dark Sky Protection In Crown Land Conservation Reserves In The Muskoka-Parry Sound District

http://www.muskokaheritage.org/ecology-night/media/chad-moore.pdf
National Park Night Skies: An Integral Element or Merely a Backdrop

http://www2.nature.nps.gov/air/lightscapes/
Natural lightscapes, including dark night skies, are not only a resource unto themselves, but are an integral component of countless park experiences.

http://www2.nature.nps.gov/air/lightscapes/monitorData/index.cfm
Natural Lightscapes Monitoring & Data

http://www.nps.gov/deva/naturescience/lightscape.htm
Lightscape / Night Sky in Death Valley National Park

http://www.nps.gov/shen/naturescience/unatural_light2.htm
Unnatural Night Light – Shenandoah National Park

http://www.astronomy.com/asy/default.aspx?c=a&id=4869
Rangers work to preserve the dark night skies above our national parks.

http://www.rasc.ca/currentjrasc/2006-dec-hr.pdf (For RASC members only)
“Beaver Hills Dark Sky Preserve”, by Bruce McCurdy, pp. 272-273

http://www.ras.sk.ca/lpc/dsp/dsp.htm
Cypress Hills Dark Sky Preserve

http://www.dcnr.state.pa.us/stateparks/parks/cherrysprings_darkskies.aspx
Pennsylvania State Parks - Cherry Springs Dark Skies - PA DCNR

http://home.hiwaay.net/~krcool/Astro/Night/darksky.htm
Dark Skies Locator

Controlling Light Pollution

http://www.recmanagement.com/feature_print.php?fid=200510fe02
Shed Some Light - How to avoid making costly mistakes when it comes to sports field lighting

http://www.newbuildings.org/lighting.htm Several important documents available:
http://www.newbuildings.org/downloads/ALG_2003.pdf
"Advanced Lighting Guidelines: 2003 Edition" - free pdf file - 445 pages, printable with GSview.
See index in 10-4 (p. 441) to find references to "Light Pollution" and "Light Trespass"
"CA Outdoor Lighting Baseline Assessment" pp.94, covers light trespass and glare
"CA Outdoor Lighting Baseline Assessment Appendices". pp 265
"CASE Initiative: Light-emitting Diode (LED) Exit Signs"

http://amper.ped.muni.cz/light/lectures/03fall.pdf
How should the light pollution be controlled?

http://www.usgbc.org/ShowFile.aspx?DocumentID=1728
U.S. Green Building Council's - The Leadership in Energy and Environmental Design (LEED®) Green Building Rating System for Core and Shell Development (LEED-CS)
- Version 2 – July 2006 (see section on "Light Pollution Reduction")

http://www.darkskysociety.org/handouts/ehmailer.pdf
East Hampton LP mailer

http://www.mtexpress.com/2003/03-08-13/03-08-13lowlights.htm
Hailey, Idaho. A valuable ordinance on lighting used as a model by many other communities

http://www.darkskysociety.org/ Long Island based

http://www.darkskysociety.org/handouts/blinded_by_the_light158k.wmv
Excellent video on Tucson

http://www.darkskysociety.org/handouts/idacodehandbook.pdf
IDA handbook

http://www.darkskysociety.org/resources.cfm?page=handouts
Useful handouts

http://www.sptimes.com/2005/01/30/Pasco/With_planning__car_de.shtml
Turn off car dealership lights by 9 pm

http://www.theage.com.au/articles/2002/08/02/1028157844148.html
Bright lights linked to Moorabbin death crash of two planes

DARK SKY Websites world wide

http://www.rasc.ca/light Royal Astronomical Society of Canada
Light Pollution Abatement Program

http://www.darksky.ch/ Swiss LP (German, Italian, French)
http://www.lichtverschmutzung.de/ German LP site
http://www.saf-lastronomie.com/cnpcn1.htm LP site in France in French
http://www.laathetdonkerdonker.nl Greenhouse LP in Dutch
http://www.platformlichthinder.nl/home.html Dutch LP site

http://www.newscientistspace.com/article.ns?id=mg18825263.700&print=true Rome dims
http://www.guardian.co.uk/print/0,3858,5328942-103681,00.html Rome is dimming its lights

http://www.rightlight6.org/english/proceedings/Session_18
Dark Skies and Planning Guidelines - See the PDF file on Shanghai Lighting Standard

http://www.publications.parliament.uk/pa/cm200304/cmselect/cmsctech/127/12704.htm
The UK Government welcomes the Committee's report on light pollution and astronomy.

http://www.defra.gov.uk/environment/localenv/light/index.htm
Local environment quality: Light pollution

http://www.iac.es/proyect/otpc/bulb.htm Spectrum, of light sources

http://www.rightlight6.org/english/proceedings/Session_14 Road Lighting

http://www.britelitesout.com Learn about Light Pollution

http://www.astrosurf.com/anpcn/congres/lpiw_2003
Light Pollution Internaional Workshop

http://www.crlaction.org
Citizens for Responsible Lighting – Right Light for Sight at Night

http://www.lco.cl/lco/spanish/light_pollution Contaminacion Luminica - Chile
http://www.darkskies4ni.co.uk Dark Skies for Northern Ireland
http://www.astro.cz/darksky Night Environment Pollution and the Remedies through Legislation and Technology, in Czechia

http://www.scn.org/darksky Dark Skies Northwest

http://www.physics.emich.edu/sherzer/nolites.html Brighton County, Mich. ordinance 1997

http://my.net-link.net/~memiller/ Michigan Dark Sky

http://www3.telus.net/~hgibbins/lightpollution Edmonton Area Light Pollution Awareness

http://www.flagstaffdarkskies.org/dollars.htm Flagstaff Dark Skies Coalition

http://www.dancaton.physics.appstate.edu/NCDarkSkies/HiCoDarkSky2.htm High Country Dark Skies

http://www.ncdarksky.org/ North Carolina Dark Sky

http://www.lightpollution.it/indexen.html Light Pollution Italy (English)

http://www.darksky.org/ida/index.html International Dark-Sky Association

http://www.lightfromabove.org Light from Above

http://www.maltastro.org/lpag Light Pollution Awareness Group: Astronomical Society of Malta

http://cfa-www.harvard.edu/cfa/ps/nelpag.html New England Light Pollution Advisory Group

http://www.iac.es/proyect/otpc/esp.htm Oficina Technica Para La Proteccion de la Calidad del Cielo - Spain

http://www.astro.cz/darksky/ Czech DarkSky in English

http://home.epix.net/~ghonis/index.htm Pennsylvania Outdoor Lighting Council

http://dynamics.org/Altenberg/PROJECTS/STARRY_NIGHTS Saving Maui's Starry Night Skies

http://selene-ny.org Sensible and efficient lighting to enhance the night time environment

http://www.texasida.org Texas Dark Sky Association
http://www.texasida.org/page_2.htm State codes

http://www.utahskies.org/lpIndex.htm Utah Skies: IDA-Utah

http://www.volt.org Virginia Outdoor Lighting Taskforce

http://www.novac.com/lp/fauquier.php Fauquier County VA Outdoor Lighting 2000

http://www.volt.org/PWCOrdinance.pdf Prince William Count VA

http://www.cfas.org/Committees/dsac.html Florida Dark Sky Advisory Committee

http://groups.yahoo.com/group/SouthernNightSkyRestorationProject/
http://groups.yahoo.com/group/SouthernNightSkyRestorationProject/links
Florida Southern Night Sky Restoration Project

http://groups.yahoo.com/group/SouthernNightSkyRestorationProject/links/3___Economic_Impacts_001026918529/
Economic Impact of Light Pollution

http://www.motherearthnews.com/Nature-and-Environment/2007-02-01/Save-Money-See-More-Stars-Green-Gazette.aspx
Save Money, See More Stars

http://britastro.org/baa/component/option,com_wrapper/Itemid,56/
http://www.britastro.org/dark-skies/busy.html
The British Astronomical Association's Campaign for Dark Skies

http://www.astrolab-parc-national-mont-megantic.org/astrolab_level05_sublevel01.html
PROJET DE LUTTE CONTRE LA POLLUTION LUMINEUSE DANS LA RÉGION DU MONT-MÉGANTIC

Light Pollution Ordinances/ Bylaws

http://amper.ped.muni.cz/light/law/Jan06/lpJan06.pdf
Rules for Protecting the Night Environment – a necessary and sufficient set

http://www.sa-ida.org/brief_summary_of_outdoor_lightin.htm
Brief Summary of Outdoor Lighting Codes

The Corporation of Delta, Council Report, Regular Meeting, by The Chief Administrative Officer, 2004, Dec 8 – staff report on proposed lighting regulation bylaw
http://www.deltaviews.com/contentengine/document.asp?id=9338

The Bylaw being amended is 4019 located at:
http://www.deltaviews.com/contentengine/document.asp?id=9499

The following example of proposed state legislation should be considered as viable approach to suggest to our BC provincial government to control light pollution across the province.

"... *Healthy, Safe, and Energy Efficient Outdoor Lighting Act*, Bill A7404 in the Assembly and S4474 in the Senate will reduce the adverse effects of poorly designed and implemented nighttime lighting.

In addition to the obvious waste of energy, resources, and dollars, a host of other problems are caused when we don't light correctly. Glare from poorly shielded lights hampers visibility. Light trespass infringes on the property rights of neighbors. The flora and fauna of our state are harmed by nighttime lighting that shines indiscriminately across their habitats. Light sent unnecessarily upwards causes sky glow, which deprives everyone the inspiration of the beautiful star-studded nighttime sky. Furthermore, wasted electricity from poor lighting leads to unnecessary air, water, and ground pollution.

This legislation will benefit not just this generation. It is a commitment to future generations to preserve and protect the beauty and inspiration of the dark night sky and to protect the health and safety of our children, the flora, and fauna of our great state."

http://www.selene-ny.org/bill.asp?&MMN_position=7:7

http://assembly.state.ny.us/leg/?bn=A07404
http://assembly.state.ny.us/leg/?bn=A07404&sh=t
http://assembly.state.ny.us/leg/?bn=S04474
http://assembly.state.ny.us/leg/?bn=S04474&sh=t

http://www.volt.org/Botetourt%20Ordinance.html
Botetourt County VA ordinance 1-1-02

http://www.co.fairfax.va.us/dpz/zoningordinance/articles/art14.pdf
Fairfax County VA Ordinance – see part 9 Outdoor Lighting Standards

http://www.arvada.org/docs/1130516123Article_6_Development_Standards.pdf
Arvada CO - lighting standards on pp. 51-58

http://www.arkleg.state.ar.us/ftproot/acts/2005/public/act1963.pdf
Arkansas State Shielded Outdoor Lighting Act 2005

http://home.silverstar.com/~jackl/tdsbasic.html
Teton Dark Skies

http://www.bouldercolorado.gov/index.php?option=com_content&task=view&id=213&Itemid=491
Boulder CO, Lighting Ordinance

http://www.co.cochise.az.us/ccwebsite/PnZ/ZoningComplaint.asp
(Light Pollution} Complaint form - to municipal government online

http://tiptopwebsite.com/websites/index.php?username=chjina&page=21
Brighton Michigan and Panama City Florida

http://tiptopwebsite.com/websites/index.php?username=chjina&page=9
Hailey Idaho

http://tiptopwebsite.com/websites/index.php?username=chjina&page=11
Flagstaff, Arizona

http://www.turtletime.org/lighting/appendix_h.htm
Model Lighting Ordinance for Marine Turtle Protection

http://www.taas.org/programs/darksky/nmnspa.htm
THE NIGHT SKY PROTECTION ACT - New Mexico

http://www.texasida.org/LocalOrdinances.htm
Texas

http://my.net-link.net/~memiller/EmmetCtyOrd.html Emmett County Ordinance 1996
http://my.net-link.net/~memiller/EmmetCtyHandout.html
Emmett County Michigan ordinance handout

The following articles show how light pollution abatement was tackled in city of Ottawa:
http://www.physics.carleton.ca/courses/astronomy/LPA/print/dick-1.htm
http://www.physics.carleton.ca/courses/astronomy/LPA/print/dick-2.htm

Here is a sample bylaw developed for Ontario regions, cities and towns,
by the Royal Astronomical Society of Canada available at:
http://www.physics.carleton.ca/courses/astronomy/LPA/home.html .
Very useful resources are: http://www.rasc.ca/lpa/index.shtml and http://www.darksky.org .

The Royal Astronomical Society --through its Light Pollution Abatement Committee-- recognises individuals, businesses and communities who adopt responsible and environmentally sensitive approaches to outdoor lighting. The tangible form of this recognition is the award of the RASC Light Pollution Abatement Program's LPA Awards (Oshawa, Calgary, Abbotsford). Certificates are awarded once per year at the annual RASC General Assembly. Delta should go after such an award.

http://www.maltastro.org/lpag/guidelines.htm
Guidelines for reduction of light pollution from Malta

http://www.astro.caltech.edu/palomar/SD%20Lighting%20Complaint%20Form.pdf
OBTRUSIVE LIGHTING COMPLAINT FORM – San Diego County

http://www.scn.org/darksky/code/index.html
Outdoor Lighting Codes in the Northwest

http://www.rasnz.org.nz/darkskies/protocol.htm
New Zealand Urban Design Protocol

In the UK light pollution is a serious problem. They call it Night Blight:
http://www.cpre.org.uk/campaigns/landscape/light-pollution/light-pollution-what-is-the-problem
http://www.cpre.org.uk/filegrab/night-blight-leaflet-a3.pdf?ref=1757
http://www.cpre.org.uk/filegrab/night-blight-report-32pp.pdf?ref=1759

In addition to providing guidelines on reducing light pollution and light trespass in Australia, the following paper also addresses the impact of lighting on crime and the *fear* of crime.
“OUTDOOR LIGHTING PRINCIPLES FOR AUSTRALIA IN THE 21ST CENTURY”,
B. A. J. Clark BSc, MAppSc, PhD, DipMechEng.,
available from: http://www.asv.org.au/lpoll/lpdoc.htm

http://www.defra.gov.uk/environment/localenv/light/pdf/lightpollution-templereport.pdf
Assessment of the Problem of Light Pollution from Security and Decorative Light
- Published Guidance/Standards on Obtrusive Light, March 2006

http://www.selene-ny.org/ordinances.asp?&MMN_position=6:6
Status of lighting ordinances in NY state communities

http://www.taas.org/programs/darksky/nmnspa.htm
Night Sky Protection Act (New Mexico 2006)

IT'S OFFICIAL - LIGHT POLLUTION IS A NUISANCE in the UK Legislation
http://www.ile.org.uk/uploads/File/01_lightpollution.pdf
http://www.ile.org.uk/uploads/File/02_lightreduction.pdf

BC Government Design Manuals
http://www.th.gov.bc.ca/Publications/eng_publications/electrical/electrical_and_traffic_eng/2004-Electrical_Signing_Design_Manual/Section%20300/Section%20300.pdf
Electrical Signing Design Manual

http://www.th.gov.bc.ca/Publications/eng_publications/electrical/electrical_and_traffic_eng/2003-Electrical_Signing_Design_Manual/Section%20300/Appendix%20300/Appendix%20300-1%20Glossary.pdf
GLOSSARY OF TERMS

ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/hwi.pdf
Highway Illumination Manual – Texas

http://delapp.com/codes/1003718.pdf Albuquerque lighting regulation staff report
http://delapp.com/codes/RevisedCOANightSkyOrd.pdf Proposed ordinance
http://delapp.com/codes/cabq-ltg-regs.php
Current area lighting regulation

http://delapp.com/codes/alamogordo.php
Alamogordo, NM

Hong Kong is invoking new international standards to control light pollution. See Section 2.3.6 Light Pollution, page 64 in:
http://www.hk-beam.org.hk/fileLibrary/_4-04%20New%20Buildings%20(Full%20Version).pdf
and
http://www.bse.polyu.edu.hk/Research%5FCentre/BEP/hkbeam/

http://delapp.com/codes/ltgordinance-taos.php
Taos, NM

http://www.rocketroberts.com/astro/litepol.htm
Light Pollution - The Bane of Astronomers (good site)

http://www.drastronomy.com/lpac/Fact_Sheet/fact_sheet.html
Durham Region Astronomical Society, Oshawa, Ontario

http://www.drastronomy.com/lpac/How_to_Help/lpabrochure.pdf
Your Guide to Responsible Outdoor Lighting

http://www.ras.sk.ca/lpc/sk_initiatives.htm
http://www.ras.sk.ca/lpc/docs/Sask_LPA_Brochure.pdf
Light Pollution Initiatives in Saskatchewan

http://www.fairfaxcounty.gov/dpz/zoning/lightingbrochure.pdf
Guide to Fairfax County's Outdoor Lighting Standards

http://www.celfosc.org/biblio/legal/llei/dogc-eng.htm
Catalonia Law (rough Altavista translation into English)

http://magma.nationalgeographic.com/ngm/0210/resources_geo6.html
News item on Czech light pollution law

http://amper.ped.muni.cz/light/law/order_draft.htm
Czech Law on Light Pollution (useful translation into English)

http://www.astro.cz/darksky/cz_law/lpNov03HR.htm
Rules for Protecting the Night Environment - a necessary and sufficient set

http://www.cielobuio.org/cielobuio/lrl17/visualreg17en.htm
European Law against light pollution

http://www.iac.es/proyect/otpc/pollu.htm
http://www.iac.es/proyect/otpc/pg3.htm
http://www.iac.es/proyect/otpc/law.htm
Sky Law in Canary Islands

http://www.tucsonaz.gov/dsd/Codes___Ordinances/Building_Codes/Proposed_Codes/2007_Outdoor_Lighting_Code.pdf
Tucson Lighting Code

http://www.tucsonweekly.com/gbase/Tools/PrintFriendly?url=%2Fgbase%2Fcurrents%2FContent%3Foid%3Doid%253A68227
Night Light – Tucson adopts code used in Pima, AZ as a model

http://www.scn.org/darksky/code/wa/bainbridge/index.html
Bainbridge Island ordinance

http://www.municode.com/index.asp
Municipal codes of US

http://www.serconline.org/darkSkies.html
Innovative states' legislation for dark skies (last updated 27 Oct 2003)

Models for related bylaws can be found in:
http://www.darksky.org/ordsregs/mlc/modlicod.html
http://www.cfht.hawaii.edu/ObsInfo/IslandLights/ordinance.html
http://www.darksky.org/ordsregs/odl-regs.html

Legal Aspects of Light Pollution

http://www.nesl.edu/lawrev/vol36/4/ploetz.pdf
Light Pollution in the United States: An Overview of the Inadequacies of the Common Law and State and Local Regulation
http://www.selene-ny.org/
Dealing with Light Trespass Problems in New York State - SELENE of NY

http://news.independent.co.uk/uk/legal/article337256.ece
On April 1, 2006 in the UK. The Clean Neighbourhoods and Environment Act 2005 comes into effect. It addresses artificial light emitted from sources so as to be prejudicial to health or a nuisance.

http://www.opsi.gov.uk/acts/acts2005/20050016.htm
See: Section 102 - Statutory nuisance: lighting which amends the Section 79 of the Environmental Protection Act 1990

http://www.defra.gov.uk/environment/localenv/legislation/cnea/statnuisance.pdf
Guidance on Statutory Nuisance from Insects and Artificial Light

http://www.lightpollution.it/cinzano/en/index.html
Stop Light Pollution in Italy

http://www.petitiononline.com/darksky/petition.html
Reducing Light Pollution in Louisiana - petition

http://www.mass.gov/legis/bills/house/185/ht00pdf/ht00808.pdf
AN ACT TO LIMIT OUTDOOR NIGHT LIGHTING, CONSERVE ENERGY, AND REDUCE LIGHT POLLUTION. Bill 808 Massacheusetts

http://www.mass.gov/legis/bills/house/184/ht03/ht03304.htm
An Act to promote Energy Efficient Outdoor Lighting - petition

http://www.publications.parliament.uk/pa/cm200203/cmselect/cmsctech/747/74702.htm
Science and Technology - Seventh Report (on light pollution)

http://www.ile.org.uk/uploads/File/01_lightpollution.pdf
Light Pollution and New Legislation

http://news.bbc.co.uk/1/hi/uk/4878686.stm
Penalties for light pollution - problems caused by obtrusive outdoor lighting - of up to £5,000 for residents or £20,000 for businesses

Light Pollution Impact on Astronomy

http://www.parliament.the-stationery-office.co.uk/pa/cm200304/cmselect/cmsctech/127/127.pdf
Light Pollution and Astronomy. (December 2003) British House of Commons papers 2003-04

http://www.ctio.noao.edu/light_pollution/iau50/
IAU Commission 50's Working Group on "Controlling Light Pollution"

http://www.atoptics.co.uk/halo/lpil.htm
Atmospheric Optics - Light Pillars

http://www.scn.org/darksky/slideshow/index.htm
This is worth Preserving - Urban Skyglow is destroying our view of the universe

http://science.nasa.gov/headlines/y2001/ast01nov_1.htm
Fading Milky Way

http://www.ctio.noao.edu/light_pollution/iau50
IAU Commission 50 Working Group on Light Pollution

http://www.astronomy.com/asy/objects/pdf/alp0604.pdf
“Reclaim the Night Sky”

http://www.lightpollution.it/dmsp
http://www.lightpollution.it/worldatlas/pages/
The Night Sky in the World

http://www.physics.emich.edu/sherzer/lightpol.htm
Our Vanishing Night

Simple steps to save the night sky
Light pollution is a growing problem, but you can help curtail it. BOB GENT
Astronomy, February 2007, pp. 72-73.

http://www.vancourier.com/issues01/03401/top1.htm
Blinded by the light

http://www.yosemite.org/naturenotes/StarryNight.htm
http://www.yosemite.org/naturenotes/NALightPollution.htm
Growth of light pollution in USA - an amazing view from space – late ‘50’s to 2025

http://skytonight.com/resources/darksky/3304136.html
Comets and Light pollution

http://www.rasc.ca/currentjrasc/2006-oct-hr.pdf see article on pp. 212-214
"Is Artificial Light at Night Too Much of a Good Thing?" by Barry Clark,
The Journal of the Royal Astronomical Society of Canada, Oct 2006, Vol. 100, Number 5
(RASC members only)

http://www.physicstoday.org/pt/vol-59/iss-10/p12.html
Saving our view of the night skies

www.lightpollution.it/download/iau06cinzano.pdf
www.lightpollution.it/download/iau06slides.pdf
www.lightpollution.it/download/iau06cinzano_poster.pdf
"Recent Progresses toward a Second World Atlas of the Night Sky Brightness" is available on the web together with the slides and a poster.

http://www.astrosociety.org/pubs/mercury/35_04/sky.html
Steering by Different Stars? Astronomers and the Dark-Sky Movement

http://www.journals.uchicago.edu/PASP/journal/issues/v112n768/200020/200020.html
Preserving the Astronomical Sky: IAU Symposium 196, July 1999 – conference highlights (IE only

http://www.journals.uchicago.edu/PASP/journal/issues/v112n770/200076/200076.html
The Spectrum of the Night Sky over Mount Hopkins and Kitt Peak: Changes after a Decade (IE only)

http://www.nctimes.com/articles/2004/03/21/special_reports/science_technology/3_20_0418_09_03.prt
Bright city lights cast shadow over studies at Palomar Observatory

http://www.astro.caltech.edu/palomar/lp.html
Light Pollution and the Palomar Observatory

http://www.smh.com.au/news/National/Will-the-last-one-out-switch-off-the-lights/2005/06/13/1118645753059.html?oneclick=true#
Will the last one switch off the lights

http://www.ndsw.org/
National Dark Sky Week

http://skyandtelescope.com/resources/darksky
Saving Dark Skies

http://www.astropix.com/HTML/L_STORY/SKYBRITE.HTM
Catching the Light by Jerry Lodriguss

http://www.unescocan.org/starlight/pdf/SLeng.pdf
STARLIGHT - A COMMON HERITAGE

http://www.unescocan.org/starlight/starlighteng.htm
International Initiative in Defence of the Quality of the Night Sky as Mankind's Scientific, Cultural and Environmental Right – conference April 2007

http://www.unescocan.org/starlight/lightpollution.htm
Light Pollution, Intelligent lighting, Energy Efficiency and Night Sky Quality – valuable links

http://www.rasnz.org.nz/darkskies/
The Case for Urban Sustainability at Night

http://www3.telus.net/~hgibbins/lightpollution/
Edmonton & Area Light Pollution Awareness Site

http://www.lightfromabove.org/
A light pollution awareness community

Measurement Techniques

http://www.astrosurf.com/anpcn/congres/GENK_2005/hanel/presentation1.ppt
A simple method to measure the sky background brightness (with a DSLR camera)

http://www.globe.gov/GaN/index.html
Participate in a worldwide campaign to observe and record the magnitude of visible stars as a means of measuring light pollution in a given location.

http://amper.ped.muni.cz/jenik/letters/public/msg00188.html
Dark Sky Meter for research

http://www.unihedron.com/projects/darksky/
Sky Quality Meter measures in magnitudes/arcsec squared
Using the conversion formula:

[value in cd/m^2] = $10.8\times10^4 \times 10^{(-0.4*[\text{value in mag/arcsec2}])}$

OpenOffice formula: =108000000*POWER(10;(-0.4*mags))
MS-Excel formula: =108000000*POWER(10,(-0.4*mags))
Where mags is the cell name that contains the mag/arcsec^2 reading.

http://www.unihedron.com/projects/darksky/sqmreport_v1p4.pdf?PHPSESSID=d13036414179d47f578b1a82cdc6e9a4
Independent Report on Sky Quality Meter

http://www.inquinamentoluminoso.it/istil/istil_laboratory.html
The ISTIL Laboratory of Photometry and Radiometry of Light Pollution (LPLAB)

http://www.lightpollution.it/cinzano/en/sbeam2.html
CCD Amateur Measurements of Sky Brightness

http://mysite.verizon.net/vze55p46/id18.html
Surface Brightness

http://dipastro.pd.astro.it/cinzano/memorie/index.htm
Measuring and monitoring light pollution

http://www.ctio.noao.edu/light_pollution/iau50/LP_working_group.htm
IAU Commission 50's Working Group on "Controlling Light Pollution"

http://www.lightpollution.it/cinzano/papers.html
Scientific papers and preprints on-line about light pollution

http://www.cegepsherbrooke.qc.ca/~graphycs/aubema/recherches/index_en.html
Light pollution research activities - sky luminance

http://www.collegesherbrooke.qc.ca/~graphycs/aubema/recherches/sand/sand_en.html
SAND: Spectrophotometer for Aerosol Night Detection

http://www.collegesherbrooke.qc.ca/~graphycs/aubema/RE28_268_0_2005-11-16_EDIT.PDF
Light Pollution Modeling and Detection in a Heterogeneous Environment:
Toward a Night Time Aerosol Optical Depth Retrieval Method

http://www.graphycs.qc.ca/publi/rapport-invent.pdf
Modélisation de l'intensité lumineuse du ciel nocturne liée à l'activité humaine

http://forum.europa.eu.int/Public/irc/dsis/giss/library?l=/working_meetings/2000_joined_meeting/dokumente_franzvsisch/egis32fr_doc/_FR_1.0_&a=d
MANTLE (Cartographie des émissions nocturnes de lumière dans l'UE à l'aide d'observations satellite des émissions dans le visible et le proche infrarouge en tant qu'outil stratégique)

http://www.ademe.fr/paysdelaloire/downloads/dge/eclairage%20public/actes032005.pdf
Actes des rencontres de l'éclairage public

http://www.graphycs.qc.ca/SAND/light-pollution.html
Light Pollution Modeling and Remote Sensing - Excellent slide presentation in English

http://www.graphycs.qc.ca/SAND/mission-ca-2005/presentations/nel/siframes.html
Estimating the light flux emitted towards the sky according to soil type and light source geometry and power - Presentation at 2005 Dark Sky

http://www.graphycs.qc.ca/SAND/mission-ca-2005/presentations/philippe/siframes.html
Method for Computerized Mathematical Modeling of the Light Pollution Phenomenon.

http://www.sciencebuddies.org/mentoring/project_ideas/Astro_p013.shtml
Measuring the brightness of the Moon

http://www.oksolar.com/technical/candela-lux.htm
Roadway lighting definition of terms

http://www.electro-optical.com Excellent tutorial material and calculators
At the threshold of vision the dark adapted observer can see a flash if it contains on average 90 photons at the cornea or 9 at the retina. This is equivalent to a candle at 30 miles on a clear night. (EOI Home page -> Education/Ref -> Candela)

http://amper.ped.muni.cz/jenik/astro/lum.php
Luminance converter

Definition:
The **candela** is the **luminous intensity**, in a given direction, of a source that emits monochromatic radiation of frequency 540 10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

The frequency chosen is that to which the eye is most sensitive. This frequency is normally referred to as the wavelength corresponding to 555 nanometers. The wavelength varies with the medium through which the light passes, so, in the interest of precision, our relatively familiar wavelength description of light is not used in the standard.

The strange choice of the number 683 is to make the value identical to that obtained with the previous version of the unit: the emission from 1 square centimeter of glowing, solidifying platinum.

The steradian is the cone of light spreading out from the source which would illuminate one square meter of the inner surface of a sphere of 1 m radius around the source.

The light intensity coming towards the observer is assumed to be reaching all angles within the enclosing steradian at the same intensity. It doesn't have to in practice: one can perfectly well measure the luminous intensity from a lighthouse beam, knowing that it actually only covers less than a hundredth of a steradian. One measures the light received by a small sensor of known area and multiplies this to give the corresponding value for one steradian.

http://www.lrc.rpi.edu/programs/transportation/lightPollution.asp?section=13.1.4
Research: Light Pollution | Transportation Lighting | Programs | LRC

http://www.lrc.rpi.edu/index.asp Lighting Research Center
http://www.assa.org.au/lightpollution/ Astronomical Society of South Australia
http://www.newbuildings.org/lighting.htm#research New Buildings Institute - Lighting
http://www.archenergy.com/lrp/lrp_reports.htm PIER Lighting Research Program

http://www.usd.edu/%7Eschieber/trb2000/sld001.htm
Photometry for Traffic Engineers

http://files.intl-light.com/handbook.pdf
The Light Measurement Handbook – Alex Ryder - An excellent resource

http://www.usd.edu/~schieber/trb2000/TRBPhotometryWorkshop.pdf
Slideshow from the Photometry for Traffic Engineers Workshop

http://www.theastrocowboy.com/Astro/SQM.htm
Sky Quality Meter (SQM) Measurements in Jackson Hole area, Wyoming

http://www.sternhell.at/howtohelp.html
Measuring the night sky visibility with a naked eye

http://www.rasnz.org.nz/darkskies/state.html
State of the Night Time Environment in New Zealand

http://www.ngdc.noaa.gov/dmsp/pres/low_light_120701/html/page10.html
World Wide Electrical Power Consumption at Night

http://www.ngdc.noaa.gov/dmsp/pres/low_light_120701/index.html
Low Light Imaging of the Earth at Night

http://www2.nature.nps.gov/air/lightscapes/monitorData/index.cfm
Natural Lightscapes Monitoring & Data

For the entire fascinating article on "Light Pollution: Efforts to Bring Back the Night Sky" see:
http://www.buildinggreen.com/auth/article.cfm?fileName=070801a.xml
plus: Minimizing Light Pollution: A Checklist for Action
http://www.buildinggreen.com/auth/article.cfm?fileName=070801a.xml&checklist=1

http://www.nytimes.com/2003/01/16/garden/16LITE.html?ei=5070&en=eba9f709842c98eb&ex=1135918800&pagewanted=print&position=top
Lights Cloud the Night Sky - Doctor Dark

http://www.mondiale.co.uk/mondoarc/iald13.html
Dark Skies Are Coming

Fixtures

http://www.cbc.ca/technology/story/2007/02/20/tech-bulb.html
Australia says lights out to incandescent bulbs

http://www.astronomy.com/asy/default.aspx?c=a&id=2202
What type of lighting emits the least amount of light pollution?

http://newsvote.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/1/hi/sci/tech/4667354.stm
Light bulbs: Not such a bright idea

http://banthebulb.org/
Save money and help the environment by using energy efficient light bulbs

http://www.darksky.org/fsa/fsa.html
http://www.darksky.org/fixtures/fixtures.html
Fixtures with Dark-Sky Friendly Fixture Seal of Approval Program

http://www.darksky.org/infoshts/is122.html
Examples of good and bad fixtures

http://www.elights.com/darksky.html
Cut Off Lighting, Friendly Lighting, or Good Neighbor Lighting

http://www.theglarebuster.com/
Shows movie on how the dark sky friendly fixture works

http://www.outdoorltg.com/
Good source of shields for outdoor fixtures

http://www.darksky.org/fixtures/manuf.html
IDA's Good Lighting Fixtures List:

http://www.rabweb.com/catalog/shades.pdf
RAB Shades:

http://www.outdoorltg.com/
Outdoor Lighting Associates (GlareBuster, Parshields, Hubbell Skycap, etc.):

https://secure.ge-lightingsystems.com/gels01/productcentral/htmls/5_0_178_catalog_156.html
GE Lighting (dropped lens/flat lens cobra head streetlight shields):

http://members.aol.com/ctcadman/shielding.htm
Homemade lighting shields:

http://www.starrynightlights.com/
Starry Nights Lights:

http://www.zonelighting.com/why_cut.htm
Lighting Effects with and without full Cut-off

http://www.parshield.com/index.html
Clip-on Glare visor

http://www.rabweb.com/common/catalog/pages/WSHADE.pdf
Full Cutoff Shades for lamp fixtures

http://www.starrynightlights.com/lpIndex.html
Source of dark sky friendly fixtures

http://www.ccrane.com/lights/led-light-bulbs/index.aspx
LED light bulbs – 26 to 200 lumens - low wattage, long life (120, 12 Volt) regular socket

http://www.roycethompson.com/pecus.php
Street Lighting Control Units

Modelling Lighting Fixtures

Examples of modeling software for lighting fixtures layouts:
http://www.visuallightingsoftware.com/Downloads/Documents/Documents.asp
http://www.lightingreality.co.uk/indexuk.htm
http://www.vialattea.net/bonata/stskyen.htm freeware
http://www.agi32.com/products.htm

Impact of Intensive Greenhouse and Hot House Lighting

http://www.bcgreenhouse.ca/documents/Growing%20Together_Delta.pdf
Good Neighbour Guidelines for greenhouse lighting (on page 2)

The following letter appeared in the South Delta Leader in Delta, BC - http://www.southdeltaleader.com/ . It is the 11th item under "Letters" to the editor posted 23 September, 2005

Potential for glow of 50.5 million light bulbs

Editor:
The BC Greenhouse Growers' Association has developed "Good Neighbour Guidelines" which state that growers using lights must:
1. Have sidewall abatement measures, such as curtains, screens, berms, or trees, for all sides that expose homes and roads to light emission.
2. Must operate their lighting systems so that the calculated light emissions from the greenhouse do not exceed 5,000 lux or there is a minimum of four hours of darkness starting at 6 p.m.

Although this is a good initial step to appease some residents affected by these intensive greenhouses, my concern is that many Delta residents and local and migrating wildlife will still be severely affected. Five thousand lux means there is 5,000 lumens per square metre permitted for each square metre of transparent surface on the greenhouse. Consider that a 100 watt bulb emits 1,700 lumens in all directions, which at a one metre distance would provide 135 lumens per square metre. The light coming through each square metre of transparent ceiling and walls would have the brightness equivalent to 37, 100 watt bulbs one metre away. Thus a greenhouse with a hectare (10,000 sq. metres) of glass ceiling would be allowed to have the brightness equivalent 370,000, 100 watt bulbs shining one metre below the glass ceiling.

It's no wonder, last winter, the clouds above the intensive greenhouses looked as if they had been illuminated by a bank of searchlights. These initial voluntary guidelines just protect the status quo for intensive greenhouse growers. They would not have to change their practices at all, e.g., add screening in the ceiling. The BC Greenhouse Growers' Association should revise its guidelines.
Delta greenhouses have 337 acres under glass. If all of them used intensive lighting, the sky would be lit up by the equivalent of 50.5 million, 100 watt incandescent light bulbs.

Your children and grandchildren will never see the grandeur and beauty of the Milky Way.

Jim Ronback
1530 Kirkwood Road
Tsawwassen, Bc
Canada V4L 1G1

+1 604 948 1589 Jim_Ronback@dccnet.com

Communication with Wim Schmidt <wim.schmidt@hccnet.nl> Dutch member of the International Darksky Association.
Greenhouses in the Netherlands produce 64% of the light produced in the Netherlands. The light is directed to the plants but of all the light going upwards 44% is still reflected from the plants and the floors in the greenhouses. So this is a big problem especially because the light is growing by a few percent every year. In Holland they now have legislation where there must be blinds which intercept 95% during the hours in the evening between 20 and 24 hour, or shut down the lamps. The plan is that this amount of 95% will be applied the whole night. It will last about another 10 years, where in the mean time there will be first 75% and later 85% but eventually it will be hopefully be 95%. There needs to be done a lot of studies to achieve that. The problem is that the moisture and the heat must escape from the plants during the night, which will be prevented by the blinds.

The information about greenhouse blinds is in the first two firms. Both of them are in English. The last link is in Dutch.
http://www.ludvigsvensson.com/Default.asp?LocationID=1&LanguageID=3
Canadian success story
http://www.bonartf.com/eng/agro_screens.html
http://kassenbouw.pagina.nl/

Greenhouse Shading links:
http://www.hydroponics.com.au/back_issues/issue25.html
http://www.hydroponics.com.au/back_issues/issue30.html
http://www.ces.ncsu.edu/depts/ent/notes/O&T/production/note104.html
http://www.uark.edu/~mrevans/4703/learning_units/unit_05/unit_05.html
http://www.longwoodgardens.org/Research_1_3_2_3_3_1.html

J. VOS & P. van BERGEM-JANSEN, "Greenhouse lighting side-effects", *Community reaction. Lighting Res Technol* 27, 1995, p. 45-51. (Not available online).

http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_AE016
Use of a blackout cloth system.

http://www.eca.gov.uk/etl/claim/
Enhanced Capital Allowance for thermal screens

http://www.laathetdonkerdonker.nl/Achtergrond/Lichtbronnen.aspx in Dutch
Glasshouse light pollution site
Go to: http://www.babelfish.altavista.com/babelfish/tr
and enter the above website URL to read it in rough English

http://www.lto.nl/pmsclient/infopage.aspx?P_PAGE_ID=5141260&P_MENU_CLICK=TRUE&P_MENU_ID=0
Greenhouse info in Dutch

http://www.laathetdonkerdonker.nl/Achtergrond/Publicaties.aspx
Action plan to reduce light pollution - in Dutch

ENERGY SAVING IN GREENHOUSE ENVIRONMENT CONTROL: HEATING, COOLING, DEHUMIDIFICATION, SCREENING

http://www.actahort.org/books/245/245_65.htm need membership to access full paper online
http://www.actahort.org/books/245/index.htm
http://www.actahort.org/books/593/593_28.htm

In a pinch, you could slowly use Babelfish to coarsely translate individual paragraphs in Dutch. Here is what the first paragraph in
http://www.infomil.nl/contents/pages/21522/besluit.pdf says:

Translated by http://babelfish.altavista.com/tr to:
"Decision of 21 February 2002, concerning rules for glass horticulture companies and for certain agriculture companies (decide glastuinbouw)"

http://www.vrom.nl/pagina.html?id=12328 in Dutch

http://www.eca.gov.uk/etl/claim/
Enhanced Capital Allowance for thermal screens

http://www.uark.edu/~mrevans/4703/index.html
Free Greenhouse Management course.

Light Pollution and Cancer and other Health Effects

http://cancerres.aacrjournals.org/cgi/content/abstract/65/23/11174
Melatonin-Depleted Blood from Premenopausal Women Exposed to Light at Night Stimulates Growth of Human Breast Cancer Xenografts in Nude Rats

Date: Sun, 04 Dec 2005 13:52:06 -0700
From: Stephen Pauley <spauley2@cox.net>
Subject: Cancer research abstract

<<Sent to me from an upstate environmentalist:
http://www.telegraphindia.com/1051202/asp/atleisure/story_5549239.asp
Susan Harder>>
==========
The research summary article in the above web site telegraphindia.com
has an **incorrect sentence:**
"Injection of blood from those women who donated during daylight or who were exposed to light while they slept had no effect on the growth of the tumours."

Actually the daylight human blood has low melatonin (mlt) as well as the human blood from the women exposed to LAN. Injection of that low mlt blood into the rats with the implanted cancer cells caused the cancer cells to proliferate, not have "no effect on the growth of the tumors."

And the low rates of tumor growth occurred when: 1) daytime blood (high mlt) was injected; 2) blood from women allowed to sleep in the dark (high mlt); 3) when mlt was added to low mlt. blood samples.

Furthermore, blocking the mlt receptor sites on the surface of cancer cells with a commercially manufactured mlt receptor blocker and preventing the uptake of mlt into cancer cells, caused cancer cell proliferation, proving that it is indeed the effects of low mlt causing the cancer cells to grow.

The protective mechanism of mlt on cancer cells works like this: the mlt molecule attaches itself to the cell membranes of the cancer cells and blocks the uptake of the nutrient linoleic acid (LA) which if allowed entry into the cancer cell will help it divide and the cancer will increase in size. Their measurements of LA levels prove this relationship.

There is no question now that mlt is indeed the protective agent IN HUMANS and we need high levels of mlt at night, i.e., we need to sleep in total darkness.

Steve Pauley MD

http://www.prevention.com/article/0,5778,s1-1-55-179-6199-1-P,00.html
The Light-Cancer Connection

http://www.israelrsa.org.il/meeting/Cancer%20incidence.ppt 21 June 2005
Light pollution as a risk factor for breast cancer: a GIS-assisted case study. A positive association was found between night light intensity
measured by satellite and breast cancer rates in towns.
JR Note: I think the units shown on slide 13 are off by 1,000,000

http://www.sciencenews.org/articles/20060107/bob9.asp
Bright Lights, Big Cancer - Melatonin-depleted blood spurs tumor growth

http://www.theglobeandmail.com/servlet/story/RTGAM.20060114.wxcancer0114/BNStory/specialScienceandHealth/
Link found between Light, Breast Cancer

http://www.darksky.org/links/pauleylhh.pdf
Lighting for the human circadian clock: recent research indicates that lighting has become a public health issue

http://www.jcircadianrhythms.com/content/2/1/4
Effects of evening light conditions on salivary melatonin of Japanese junior high school students

http://taylorandfrancis.metapress.com/content/?k=Circadian+Dysfunction+Reduces+Lifespan+in+Drosophila+melanogaster
Circadian Dysfunction Reduces Lifespan in *Drosophila melanogaster (fruit fly)*

http://taylorandfrancis.metapress.com/content/?k=Working+Under+Daylight+Intensity+Lamp
Working Under Daylight Intensity Lamp: An Occupational Risk for Developing Circadian Rhythm Sleep Disorder?

http://jp.physoc.org/cgi/content/full/526/3/695
Sensitivity of the human circadian pacemaker to nocturnal light: melatonin phase resetting and suppression

http://www.redorbit.com/modules/news/tools.php?tool=print&id=96637
Lighting Innovations Prevent Disease

http://www.iald.org/pdfs/Light_and_Dark_The_New_Drugs.pdf
LIGHT AND HEALTH: THE NEW DRUGS

http://www.sunshinesales.ca/home.htm
Bright Light Photo-therapy for Seasonal Affective Disorder

http://www.medicalnewstoday.com/medicalnews.php?newsid=61808
Light At Night Is Dangerous To Health

http://www.muskokaheritage.org/ecology-night/media/steven-lockley.pdf
Effects of Light on Human Circadian Rhythms

http://www.lrc.rpi.edu/resources/newsroom/architecturalLighting.asp
Recent scientific studies claim to demonstrate a link between architectural lighting and cancer growth.

http://amper.ped.muni.cz/noc/english/Can_and_Rhythm.htm 4 abstracts
Disturbance of circadian processes by lack of dark: first results of blood-pressure monitoring
Sleep disturbances by light at night: two queries made in 2003 in Czechia -
Faint light at night: which levels are disturbing, how to estimate and measure them
Melanopsin-registered irradiation: measurement by digital cameras.

http://www.apollolight.com/pdf_files/NEL.pdf
"Ocular Input for Human Melatonin Regulation: Relevance to Breast Cancer", Glickman, Levin and Brainard, Neuroendocrinology Letters 2002; 23(suppl 2):17-22

http://jncicancerspectrum.oxfordjournals.org/cgi/reprint/jnci;95/11/825.pdf
Night-Shift Work and Risk of Colorectal Cancer in the Nurses' Health Study

http://www.nytimes.com/2006/04/25/health/25real.html
The Claim: Artificial Light Can Increase Breast Cancer

http://www.bcaction.org/Pages/SearchablePages/2000Newsletters/Newsletter061A.html
What Light Through Yonder Window Wreaks—Circadian Rhythms and Breast Cancer

http://www.optometrists.asn.au/gui/files/ceo866363.pdf
Vos, J. J. (2003) "On the cause of disability glare and its dependence on glare angle, age and ocular pigmentation." Clinical and Experimental Optometry, 86(6), 363-370.

Best review on Glare according to Barry Clark.
Vos, J. J. (2003) Reflections on glare. Lighting Research and Technology, 35(2), 163-176.

http://www.usd.edu/~schieber/pdf/glare.pdf
Age & Glare Recovery Time

http://www2a.biglobe.ne.jp/~wakaba/lp/glare%20and%20aging%20eyes.pdf
Glare and aging eyes – Shigemi Suchida *light_consult@infoseek.jp*

http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=8084491&dopt=Abstract
The NMDA antagonist MK-801 blocks light effect on melatonin receptor density in rat suprachiasmatic nuclei.

http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=9042530&dopt=Abstract
Caffeine and light effects on nighttime melatonin and temperature levels in sleep-deprived humans.

http://lib.tkk.fi/Diss/2005/isbn9512278685/
Development of Visual Performance Based Mesopic Photometry

Environmental effects of artificial light and light pollution

http://www.environmentaldefense.org/documents/3820_Solutions_07_04.pdf
Bring back the night - LIGHT POLLUTION BEWILDERS BIRDS, WASTES ENERGY AND ERASES STARS FROM THE SKY - page. 10

http://www.muskokaheritage.org/ecology-night/media/robert-dick.pdf
Excellent PowerPoint presentation by Robert Dick of RASC

http://www.darkskysociety.org/handouts/UnderstandingtheEffectsofLightPollutiononWildlife.ppt
Effects of Light Pollution on Wildlife - Excelent presentation

http://www.muskokaheritage.org/ecology-night/media/monte-hummel.pdf
Saving the Night Sky: Less Talk More Action

http://www.muskokaheritage.org/ecology-night/media/wise-buchanan.pdf
The Impact of Artificial Night Lighting on Nocturnal Amphibians

http://www.dailynexus.com/article.php?a=9696
Pole Collisions Cause Deaths of Migrating Birds

http://www.jsonline.com/news/metro/oct05/367139.asp
Program sheds light on perils for feathered fliers

http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?tp=&arnumber=917060&isnumber=19808
New solutions for bird collision and electrocution outage problems

http://www.kiuc.coop/pdf/shearwaters.pdf Hawaii
What KIUC [Kaua`i Island Utility Cooperative] is Doing to Help
"Over the past two years, KIUC has replaced all unshielded streetlights along county and state highways. By eliminating stray light, it has reduced the number of young birds that get confused and land rather than continuing to sea."

http://www.urbanwildlands.org/Resources/LongcoreRich2004.pdf
"Ecological Light Pollution" in Frontiers in Ecology and the Environment

http://www.darkskysociety.org/handouts/pauley.pdf
Lighting for the Human Circadian Clock:

http://www.americanscientist.org/template/AssetDetail/assetid/14559
Effect of night light on aquatics

http://www.ces.purdue.edu/extmedia/FNR/FNR-FAQ-17.pdf
Does Night Lighting Harm Trees?

http://www.muskokaheritage.org/ecology-night/
Ecology of the night - scotobiology

http://media.cbc.ca:8080/ramgen/cbc.ca/thecurrent/media/200310/20031001thecurrent_sec2.rm
CBC interview on Ecology of the Night

The following item was published on 8 January 2005 in the Delta
Optimist, and later in the Vancouver Sun:
"Effects of Light Pollution on the Environment of the Fraser River Estuary", by Anne Murray

For its effects of light pollution on the environment see:
http://www.darksky.org/links/enviro.html

http://magazine.audubon.org/darksideoflight.html
This item in the Audubon magazine is a good article on
the "Dark Side of light" on the effects of night time light pollution on fauna.

http://www.flap.org/new/nestegg.htm
Fatal Light Awareness Program

http://www.darksky.org/infoshts/is076.html
Exterior Lighting: Glare and Light Trespass

http://www.rasc.ca/light/
Royal Astronomical Society of Canada – Light Pollution Abatement

http://newsvote.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/1/hi/england/derbyshire/4512930.stm
Bird watchers believe the pair of falcons has been using the lights of the city centre to help them hunt for prey.

http://www.google.com/search?ie=UTF-8&oe=UTF-8&sourceid=gd&q=scotobiology
Biology of the night - scotobiology

http://amper.ped.muni.cz/noc/english/res_plan2004.html
Light as a Pollutant of the Night Environment: reality, impacts, remedies

http://www.butterfly-conservation.org/species/moth_faqs/004.php
Light pollution seriously affects moths

http://www.sciencenews.org/articles/20020420/bob9.asp
Deprived of Darkness - The unnatural ecology of artificial light at night

http://www.sdaa.org/_docs/_light/LP_BangorDailyWood.pdf
Light pollution has unforeseen consequences to nature

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Road lights and behaviour of some common mammals

http://www.astrosurf.com/anpcn/congres/GENK_2005/demolenaar/godwit.ppt
The impact of lighting on the godwit

PROTECTING DARK SKIES / Guest Editor: Joe Sovick – George Wright Forum, See Volume **18:4 (2001)**
http://www.georgewright.org/backlist_forum.html

- Toward an Appreciation of the Dark Night Sky / Joe Sovick
- The Value of Dark Skies and of High-Quality Night Lighting—Building Public Awareness / Elizabeth M. Alvarez del Castillo and David L. Crawford
- The Ultimate Cultural Resource? / Jerry Rogers and Joe Sovick
- Preserving Pristine Night Skies in National Parks and the Wilderness Ethic / Dan Duriscoe
- Let There Be Dark: The National Park Service and the New Mexico Night Sky Protection Act / Jerry Rogers and Joe Sovick
- Visual Estimations of Night Sky Brightness / Chadwick A. Moore
- Modeling Light Pollution from Population Data and Implications for National Park Service Lands / Steve Albers and Dan Duriscoe
- Stargazing—A Driving Force in Ecotourism at Cherry Springs State Park / Thom Bemus
- Chaco's Night Lights / Brad Shattuck and G. B. Cornucopia
- Light Pollution and Marine Turtle Hatchlings: The Straw that Breaks the Camel's Back? / Mark Nicholas
- Yellowstone by Night / Lynn Chan and Eleanor Clark

http://www.selene-ny.org/resources.asp?&MMN_position=10:10
PowerPoint presentation on "environmental effects" plus the flyer for NY

Reference list on environmental effects of Light Pollution from:
http://www.lightpollution.it/cinzano/refer/index.htm

N.B. This section D is under construction by Mr. Cinzano and it collects only a small and incomplete list of references.

by Pierantonio Cinzano

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Basic principles for Wildlife Lighting

…. As one of the Environmental Specialists working on the U.S. Wildlife Lighting Program, I was asked to respond to your email request. Yes, we are doing a large amount of ground work right now in the United States with Wildlife Lighting Partners including the U.S. Fish and Wildlife Service, The National Park Service, the USDA Forest Service and the Florida Fish and Wildlife Conservation Commission (Florida accounts for approx. 90% of sea turtle nesting in the U.S.)

Some basic principles for "Wildlife Lighting" have emerged that are fairly easy to adopt and seem to benefit the largest number of species. First and foremost -- we have found there is NO SUBSTITUTE FOR NATURALLY DARK HABITAT. Artificial lighting should only be used where and when needed for safety and security in wilderness areas. Timers and motion sensors can be good tools but ONLY when attached to Wildlife Lighting Fixtures and lamping. Wildlife Lighting Fixtures and lamps should never be installed as an excuse to introduce artificial light sources where none are needed. Wildlife Lighting and Dark Sky Lighting has broad overlap but they are not quite the same thing. Dark Sky Friendly fixtures can still be highly damaging to wildlife when installed in the wrong locations.

The Three Criteria of Wildlife Lighting:

1) *Keep it Low* (mount the fixture as low as practicable for the illumination task. Path lights, shielded bollard lighting and louvered step lights are good examples. Avoid floodlights and pole mounted fixtures whenever possible. The higher the fixture is mounted -- the harder to shield and the more atmosphere the photons must pass through. _Keep it low_ also refers to the lumens output. Use only the amount of light needed to take advantage of natural human night adaptive - mesopic and scotopic - vision)

2) *Keep it Shielded* (Fixtures must be fully shielded and downward directed. The IES Classification of full cut-off (FCO) is a good starting point. No filament, bulb, or glowing lens should be directly visible from the wilderness area, wetland, natural buffer, beach, park, or migratory corridor. Many fixtures are available with house-side shields (HSS) that must be used to block light trespass visible from the wilderness area.

3) *Keep it Long* (Long wavelength light sources have been found to be less disruptive to many nocturnal animals. These light sources appear yellow, amber or red to the human eye. Examples include Amber LED bulbs, low-pressure sodium lamps, Red LED bulbs, some low wattage yellow "bug" lamps, and TSL filtered compact fluorescent. Energy efficient lamps also increase the total score on the Wildlife Lighting review because they help protect natural resources by decreasing
energy consumption.)

The question about "Green" colored lighting being more acceptable to wildlife is an old one. We actually have hunters to thank for this. Years ago, many hunters figured out that green filters over their flashlights removed the highly disruptive UV, violet and blue short wavelengths. Many animals (particularly large ungulates such as deer, elk, moose and even hogs) were less disturbed and continued to forage and migrate in the presence of this green light. Our spectral analysis showed this light to be about 520nm and longer. Almost no wavelengths were shorter than ~ 520nm with these "hunter's flashlights." We quickly discovered a HUGE problem with green colored lights. Although many game species such as deer may be less disturbed by this light, many other species including sea turtles, migratory birds, and some small mammals (endangered beach mice) are disrupted by green light. Although their response appears to be less than with polychromatic (white) light sources -- the level of disturbance was (is) still unacceptable to be considered "Wildlife Lighting."

The answer was to shift even further down the light spectrum and look for response(s). Just past green you hit the yellow / amber / red end of the light spectrum. Even though there is a benefit even with standard incandescent yellow "bug" bulbs, the ability to filter short wavelengths varies wildly from bulb manufacturer to manufacturer. We really started to see a benefit from light filtered to remove all wavelengths 580nm and shorter. The benefits were almost exponential as you move to longer wavelength light. Red LEDs (648nm to 660nm depending on manufacture) had to be approximately 200 times as intense as a polychromatic (white) light source in order to see a similar response in sea turtles. The same held true for researchers working with bats. Red LED flashlights could be taken into bat roosts with almost no disturbance to sleeping bats. White headlamps (or flashlights) caused the bats to fly back and forth. The bats appear agitated.

When lights are needed, the best balance has proven to be 580nm or longer. Here we see humans readily accept amber colored light as being "romantic" easy to see and navigate in low-light conditions and many people are already comfortable in this type of "nocturnal light conditions" in theater lighting, sunsets, restaurant and step lights.

Here is how the best lamps spec'ed out:

Amber LED diodes (590 -- 591nm)

Low-pressure sodium (589nm peak spectral)

Red LED diodes (648 to 660nm)

Yellow "bug" bulbs (525 -- 550nm --acceptable only in lower wattage and lower lumens output)

TSL filtered CF (620 to 648nm peak spectral)

It is important to remember that light wavelengths are only one of the three criteria for Wildlife Lighting. Fixtures must meet ALL THREE WILDLIFE LIGHTING CRITERIA to be considered acceptable. Only those fixtures and lamps submitted to the USFWS and/or FWCC that successfully pass lighting inspection (No uplighting and minimal lateral light trespass) and wavelength analysis receive certification and permission to use the Official Wildlife Lighting logo device in marketing materials.

Some fixtures and lamps that may help you in your path lighting project:

http://www.wfharrislighting.com/store/index.php?catid=61

https://store.lsgc.com/R30-AMBER-BUG-LIGHT-LONG-CONE-P38C0.aspx

http://www.state.hi.us/dlnr/dofaw/fbrp/sos.htm

Good luck!

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Florida Fish & Wildlife Conservation Commission
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Imperiled Species Management Section
620 South Meridian Street
Tallahassee, FL 32399-1600
PHONE (850) 922-4330 FAX (850) 921-6988
dean.gallagher@myfwc.com <mailto:dean.gallagher@myfwc.com>
visit www.MyFWC.com/psm <http://www.MyFWC.com/psm>

Politics of Light Pollution

http://leportique.revues.org/document542.html#bodyftn9
Comment la différence entre nuit et jour s'émousse sous le modèle de Polder aux Pays-Bas

> This (French) article examines the discursive game concerning the night. The Netherlands, as a small country, has the highest density of population in Europe. This fact explains to some extent that the night as a portion of the day without light tends to disappear in many parts of the Netherlands. But this phenomenon constitutes also an area of political and economic struggle. That is why a new terminology has been invented by the main players, such as the government, as for example the term 'the margins of the night', with the aim to control and to manipulate the political decisions affecting the use of artificial lightning. Even the ecological movement and the National Council of Health did participate in creating a new terminology. These new discourses are widely used, and the fact of their existence and their use have consequences on what "is" the night in the Netherlands.

http://bbs.keyhole.com/ubb/showthreaded.php?Cat=&Board=EarthNature&Number=269838&Searchpage=1&Main=269838&Words=%26quot%3Blight+pollution%26quot%3B&topic=&Search=true#Post269838
Light Pollution Overlay of North America – needs Google Earth installed.

http://bbs.keyhole.com/ubb/showthreaded.php/Cat/0/Number/269432/an/0/page/0#269432
Light Pollution overlay for all of Europe – needs Google Earth

http://bbs.keyhole.com/ubb/showthreaded.php/Cat/0/Number/1583/an//page/0/vc/1
Earth at night – needs Google Earth

http://www.lipower.org/commercial/lightsol/
http://www.lipower.org/pdfs/company/pubs/brochures/lightsolutions.pdf
http://ewweb.com/mag/electric_night_sky_gets_2/
The Long Island Power Authority LIPA Improves Night Sky Over Long Island with Dark Sky Friendly Lighting Fixtures

http://newyork.sierraclub.org/longisland/lightpollution.html
What is light pollution? Sierra Club – Long Island Group

http://www.selene-ny.org/bill.asp
Proposed - The Healthy, Safe, and Energy Efficient Outdoor Lighting Act (Bill A7404/S4474)

http://amper.ped.muni.cz/light/ida/2005report.pdf
Czech IDA report 2004 - 2005 – in English

http://amper.ped.muni.cz/light/shielding/why_fs.pdf

Three reasons why full shielding is indispensible

http://news.bbc.co.uk/1/hi/sci/tech/4755996.stm
Ground-based astronomy could be impossible in 40 years because of pollution from aircraft exhaust trails and climate change

http://www.iea.org/Textbase/press/pressdetail.asp?PRESS_REL_ID=182
http://www.iea.org/w/bookshop/add.aspx?id=302
Light's Labour's Lost -- *Policies for Energy-efficient Lighting*
The figures on the above web page are amazing. Worldwide, grid-based electric lighting consumes 19% of total global electricity production. Globally, lighting consumes more electricity than is produced by either hydro or nuclear power and results in CO2 emissions equivalent to two thirds of the world's cars.

http://observe.phy.sfasu.edu/observatory/images/20020106/Misc/Premcor/IDA_Newsletter_reference.rtf
June 2000 ….. By installing shields on existing lights, Mr. Taylor found that the wattages could be reduced because the glare level was lowered and more light was redirected to the area to be lit. … 20,000 lights will be converted to fully shielded, and as the units need to be repaired, the lamp wattages will be lowered. When this project is completed, the annual savings in energy costs at the Premcor Refinery will be $172,920. This figure is based upon an energy cost of $0.033 per kwh. Note that the power rates fluctuate, and usually, the plant pays less than this for energy. However, during high power demand periods, the plants energy costs increase by several factors. In recent summers, the area around Houston, Texas, has been hit by rolling brownouts when power generation capacity could not meet demand.

http://www.jstage.jst.go.jp/article/jlve/28/1/58/_pdf
Evaluation of light pollution compared with other major environmental issues in Japan:

http://www.wyp2005.at/glob1-light.htm
April 18, 2005 lights were switched off in Princeton, NJ, to commemorate the 50th anniversary of Einstein's death.

EXAMPLE ORDINANCES

http://www.amlegal.com/nxt/gateway.dll/New%20Mexico/albuqwin/cityofalbuquerquenewmexicocodeofordinanc?f=templates$fn=default.htm$3.0$vid=amlegal:albuquerque_nm_mc$anc=que_nm
Albuquerque Code of Ordinances – needs Java plugin

§ 14-16-3-9 AREA LIGHTING REGULATIONS.

(A) The location of the lighting fixture together with its cut-off angle shall be such that it does not directly shine on any public right-of-way or any other residential premises;

(B) It shall not have an off-site luminance greater than 1,000 footlamberts; {3426 nits) and it shall not have an off-site luminance greater than 200 footlamberts (685.2 nits) measured from any private property in a residential zone.

(C) Where on-site lighting is provided, the location of all light poles shall be indicated on the site plan.

(D) For sites smaller than five acres, the maximum height of a light pole, measured from the finished grade to the top of the pole, shall be 20 feet.

(E) For sites five or more acres, the maximum height of a light pole, measured from the finished grade to the top of the pole, shall be 30 feet.

(F) The maximum height of a light pole, measured from the finished grade to the top of the pole, within 100 feet of a residential zone shall be 16 feet.

14-16-3-5 GENERAL SIGN REGULATIONS.

(B) *Regulations Applicable to Signs in All Zones.*

(1) Prohibited Signs. The following signs are prohibited and shall be removed or brought into conformance in accordance with § 14-16-4-11 of this Zoning Code:

(a) Signs contributing to confusion of traffic control or resembling traffic control lighting; unauthorized signs, signals, markings or devices which purport to be or are imitations of official traffic control devices or railroad signs or signals, or signs which hide or interfere with the effectiveness of any official traffic control devices or any railroad signs or signals.

(b) Unauthorized signs, installed after June 17, 2002, which attempt to control traffic on the public right of way.

(c) Signs, except wall signs, in a clear sight triangle.

(d) The copy on signs which advertise an activity, business, product, or service no longer produced or conducted on the premises upon which the sign is located unless they can meet

requirements for a new off-premise sign. Where the owner or lessor of the premises is seeking a new tenant, such signs may remain in place for not more than 30 days from the date of vacancy.

(e) Rotating, pulsating or oscillating beacons of light, including searchlights used for commercial or promotional purposes.

(f) Signs with audible devices.

(g) Free-standing signs with overhead wiring to supply electric power; however, off-premise signs are excluded unless underground power lines supply the site.

(h) Permanent Directory Signs. One permanent sign identifying and giving directions to businesses in an industrial park controlled by the IP or SU-1 zone shall be permitted at each entrance to the industrial park. Illumination shall be in accordance with the restrictions set forth in this section. Such signs' areas shall not exceed 1.5 square feet per business in the industrial park.

(i) Canopy signs, the bottom of which is less than seven feet above grade.

(j) Building-mounted signs which extend above the wall of the building and which do not have sign supports covered in a manner which integrates the sign with the building design. (Angle irons or similar supports shall not be visible from public right-of-way; guy wires or cables may be visible).

(k) Signs with high intensity electronic discharge strobe lights.

(l) Off-premise sign, any part of which is located within six hundred sixty feet of the nearest edge of the right-of-way of Interstate 25 between the northern and southern boundaries of the City, and within six hundred sixty feet of the nearest edge of the right-of-way of Interstate 40 between the eastern and western boundaries of the City.

(2) Prohibited Locations.

(a) No sign shall have its lowest point less than 12 feet above the ground over public right-of-way except those signs specified in Subsection 14-16-3-5(F) of this Zoning Code.

(b) No sign facing, except a wall sign or a one-square-foot address sign, shall be between three and eight feet above the gutter line within ten feet of a street public right-of-way line except those signs specified in Subsection 14-16-3-5(F) of this Zoning Code.

.....

(C) *Regulations Applicable to Signs in or Within 40 Feet of Residential Zones.* The additional provisions of this section apply to all signs in a residential zone or within 40 feet of a residential zone. In the case of a nonresidential zone within 40 feet of a residential zone, the more restrictive of these regulations or the regular sign regulations in the nonresidential zone shall apply.

(1) No portion of an illuminated sign shall have a luminance greater than 200 footlamberts (685.2 nits) at night.

(2) No sign nor part of a sign shall move, flash, or rotate. No sign or part of a sign shall change its illumination more than once an hour.

(3) No more than one sign per premises shall be illuminated, apart from the general illumination of the premises, between 10:00 p.m. and 7:00 a.m.

Note: 1 footlambert = 3.426 nits = 3.426 candelas/ square meter

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Light Pollution – NLPIP Lighting Answers – Volume 7, Issue 2, March 2003, 19pp
http://www.lrc.rpi.edu/programs/NLPIP/publicationdetails.asp?id=884&type=2

Allowable range of the lumens being emitted up and in the glare zone

Luminaire classification	Range of allowable lumens emitted upward	Range of allowable lumens emitted between 80° and 90°
Full cutoff	0	0 - 11%
Cutoff	0 - 16%	0 - 11%
Semi-cutoff	0 - 31%	0 - 22%

http://www.wcel.org/issues/urban/sbg/Part3/darksky/
Smart Bylaws Guide – Dark Sky Regulations

http://www.gov.saanich.bc.ca/municipal/clerks/bylaws/zone8200.pdf#page=199
Saanich, BC - Municipal Outdoor Lighting Standards, pp 213-216

http://www.darksky.org/resources/information-sheets/pdf/is055.pdf
Dark-Sky Ordinance 90.02, Tempe, Arizona

-------- Original Message --------
Subject: RE: [OL-Forum] Shielded Outdoor Lighting Legislation may be a political football
Date: Tue, 7 Mar 2006 00:46:57 -0500
From: Nickas, George <nickas@hanover.edu>
Reply-To: OutdoorLighting-Forum@yahoogroups.com
To: <OutdoorLighting-Forum@yahoogroups.com>

This is sheer extortion and intimidation and should be fought. If you downsize the wattage as you should with shielding, you can recoup the installation fee (a 100 watt reduction saves 10 cents a day operating cost) in a few short months. Please don't tell me they plan to shield and not downsize wattage.

George

-----Original Message-----
From: OutdoorLighting-Forum@yahoogroups.com on behalf of patric
Sent: Mon 3/6/2006 8:00 PM
To: OutdoorLighting-Forum@yahoogroups.com
Subject: Re: [OL-Forum] Shielded Outdoor Lighting Legislation may be a political football

Pat wrote:
> Here's an example in the news showing how some can fight legislation
>
http://www.nwanews.com/adg/News/147682/

"So far, 19 (utility) companies have filed tariff requests and almost all have asked the commission to approve what the league says are significant increases.

The companies offer a wide variety of options, and the costs of changing to shielded lights varies. However, the company said that the monthly cost of one variety of light - a 250 watt high pressure sodium light - would rise from $7. 02 to $ 13. 37."

Why does the term "fraud" come to mind? Check the lighting manufacturers and see which the cheaper light is, the one with the flat lens or the one with the hard-to-manufacture refractive bowl?

"Steve Strickland, Entergy Arkansas' vice president of regulatory affairs, said that increased monthly costs will primarily cover Entergy's expenses for building a new light post."

And where do they get the idea that shielded lights need new posts? Could it be yet another gross mis-interpretation about pole spacings for continuous lighting systems that dont take into account RP-8-00's Alternating Contrast concept of the Small Target Visibility method?

(RP-8-00 also recommends pavement luminance levels be substantially lower than previous recommendations when STV criteria is used (pp52) so there may be a

savings in energy that can assist in offsetting the cost of the upgrade -- and possibly explain why it's unpopular with utilities). I dont see any indication that is being done in Arkansas.

I would really like to see David Kieth update his work to take Alternating Contrast into consideration, and give the unscrupulous corporations one less body of research they can bastardize.

OutdoorLighting-Forum - "The largest uncensored and most active forum on light pollution."

-------- Original Message --------
Subject: Re: [OL-Forum] Re: AASHTO uplight discussion
Date: Tue, 7 Mar 2006 10:39:00 -0600
From: George Nickas <nickas@hanover.edu>
Reply-To: OutdoorLighting-Forum@yahoogroups.com
To: OutdoorLighting-Forum@yahoogroups.com
References: <1141640209.142.83685.m19@yahoogroups.com>
<007601c64163$2dacb9a0$3f02a8c0@samiam>

When you design lighting and lighting regulations from the sky down instead of the ground up, like Mr. Keith et al, interesting things happen. Suppose you decide and pass a sky protection regulation that only U lumens will be permitted to go into the sky from any luminaire you put outdoors. The determining factors then on the power of the luminaire is ground reflectivity, and much more importantly, direct uplight emitted by the luminaire.

One can then calculate a very simple and elegant table showing the limiting power of the luminaire in one column with the spill factor (fraction of P lumens that is direct uplight--call it f) as the independent variable. For FCO, f=0, or for a luminaire that spills 15% directly up, f=0.15 and so and so on. Here is the table based on Mr. Keith's 18% ground reflectivity.

f=	0	0.05	0.10	0.20	0.30	0.50
limiting P/U=	5.5	4.52	3.82	2.91	2.32	1.69

Explanation: With a regulated uplight limit, you can power a luminaire up to 5.5 times the permitted uplight lumens when at full cut-off (f=0). But if you spill 30% up directly from the luminaire, your luminaire power is limited to only 2.32 times your uplight lumens. This is drastic and dramatic and shows how significant direct uplight is. There would be no controversy about spacing and the rest of the obfuscating technicalities were we to design lighting from the sky down. If you spill 10% then your luminaire power must be no more than 3.82 times the regulated uplight limit.

When you decide how much light you want into the sky with sky-down regulation of lighting, it puts all the onus on the designers to produce a design that

meets the uplight criterion while satisfying their down-lighting specs, and gets the rest of us out of the useless and never-ending business of arguing about arbitrary spacing and other standards. Seize the sky! How many lumens are we willing to tolerate going up from a streetlight or porchlight or landscape light or whatever else?
Designers--Meet the spec or beat it!

George

On Mar 6, 2006, at 3:15 PM, David Keith wrote:

C.R. wrote:
>> From experience, the maximum spacing for full-cutoff or cutoff luminaire is about 5% closer then a semi-cutoff design which may make the road or parking lot 5% brighter. Assuming 10% ground refectivity, which is probably high, then the reflected light would only increase 1/2%. >>

What? If there are 5% more lumens installed, where are they going? The *reflected* light was already times the 10% reflection value - so *reflected light* increases by (at least) 5% too! (I suspect the idea was to say uplight from reflection increases 1/2% - but that's also wrong! If system total uplight goes from say 1% of installed lumens to 1.5%, is that a 0.5% increase or a 50% increase?)
Based on research using thousands of designs optimized for specific combinations of photometry, roadway, system geometry and design criteria - published in papers in the Journal of the IESNA - I find that this opinion is roughly correct but *significntly* underestimates the effects of the reflected light.
First the spacing difference can be much greater - easily 8-20% - depending on the design criteria and suitability of the photometric distribution. There are values shown in the uplight calculation example at
http://resodance.com/mdi/UUDcalc.html
and the photometry and details are available there, so anyone (who is technically capable) can reproduce these results for themselves. ("They" can also play with reflectance values to see the significance of off-roadway reflectance in total uplight.) The difference in *spacing* for the four lane major roadway shown there is from 103m to 111m - about one-and- a-half times the difference cited above.
The situation is much more dramatic for narrower roadways and lower levels of lighting, and especially when luminaires are not allowed to overhang the roadway. A quick look at the research numbers show that for two lane collector roads with 175W MH sources using illuminance based design, the BEST (longest) spacing is 78m for FC vs 90m for SC - a difference of about 15%. For 150W HPS, the values are 114m for FC and 127m for SC (11% difference) - and with "zero overhang allowed" the FC drops to 107m while the SC stays at 127m (19% difference). So research shows that the spacing *difference* may be as much as 3-4 times that of the opinion expressed above. (This also shows how optimization can produce designs that are much more efficient than those based on common practice.

Note that this does not mean that for two "comparable" designs, the spacing difference *is* that big - almost anyone can underdesign a lighting system and use more equipment than necessary (e.g., see typical DOT standards). Also many real designs have conditions or restrictions that lead to "less-than-optimal" solutions.
Second - the reflectance of the roadway and surroundings has been discussed here - but 10% is low for "everything" that light will reflect from outdoors. Most anything other than asphalt or green plants has significantly higher reflectance. For example - using values from NASA's ASTER library of reflectance data - dry grass is about as reflective as "light concrete" - around 30-35%. Sand and snow are of course MUCH higher - and cars, vans and trucks may be polished to a shiny gloss and parked right under the lights. I still think the most reasonable value for "ambient outdoor reflectance" - averaged over time, space, climate, direction etc. - is the one adopted by Kodak as their basis for outdoor photography - 18%. This would correspond to about double the reflection of uplight compared to the scenario in the above opinion.
Also - the opinion above assumes that the portion of light off the roadway stays the same for different distributions and spacings - but the difference in distribution is WHY the spacing *must* be changed. The luminaire efficiency is roughly the same - the luminaires have roughly the same number of lumens escaping *per luminaire* and with shorter spacing, the possibilities are limited - either the system is too non-uniform, too bright on average or spilling more onto the off-road surfaces. For FC in optimized systems (because the spacing is shorter and the average lighting level is roughly the same and the uniformity is roughly the same) less lumens per luminaire are landing on the roadway, so more land off the roadway. The reflectance of asphalt is lower than almost anything outdoors - so all light going off the roadway will be reflected much more (18%) than light onto an asphalt roadway (7%) - and this is where the difference in light output is going - onto surfaces that are probably much more reflective than the roadway! Altogether - for roadways - differences between FC and other distributions published in research papers are roughly 6-10 times as great as the differences cited in the opinion above. Differences (e.g. in installed lumens) due to spacing in parking areas are typically the square of the differences from spacing for linear roadways - but of course the reflectance is much more consistent, as much less light tends to "miss" the parking area.
There is a complete technical discussion of the roadway research and the associated work published in the JIES at
http://resodance.com/ali/tm_toc.html
Furthermore, last week I received copies of work performed in Europe that is consistent with these results and will be working to get those papers posted on the web soon.

David Keith

OutdoorLighting-Forum - "The largest uncensored and most active forum on light pollution."
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http://www.resodance.com/ali/bluskies.html
What Blue Skies Tell Us About Light Pollution

http://resodance.com/ali/home.html
Alliance for Lighting Information

http://www.bbc.co.uk/radio3/betweentheears/pip/9mx3t/
The darkest place in England - Radio 3
Poet Lavina Greenlaw goes in search of the endangered dark. Is true darkness to be found anywhere? With photographer Garry Fabian Miller and literary critic Alan Downie.

http://members.aol.com/dsfportree/alphp.htm
Flagstaff's Battle for Dark Skies

http://www.urbanwildlands.org/conference.html
Ecological Consequences of Artificial Night Lighting: Conference

http://www.cpre.org.uk/filegrab/night-blight-report-32pp.pdf?ref=1759
Night Blight in the UK

http://www.crlaction.org/
The Citizens for Responsible Lighting

http://www.pollutiononline.com/Content/News/article.asp?DocID=%7B84ABB0F3-D5E6-11D4-A76E-00D0B7694F32%7D&VNETCOOKIE=NO
Japan may issue light-pollution law

http://www.theglobeandmail.com/servlet/GIS.Servlets.HTMLTemplate?tf=tgam/common/FullStory.html&cf=tgam/common/FullStory.cfg&configFileLoc=tgam/config&vg=BigAdVariableGenerator&date=20020112&dateOffset=&hub=comment&title=Comment&cache_key=comment&current_row=1&start_row=1&num_rows=1
Blinded by the light, 2002 Jan 12

http://www.kingluminaire.com/darksky.asp
Addressing dark sky concerns

http://amper.ped.muni.cz/light/drafts/graphics/scatt_en.pdf
Why the sky over your town and even far from it glows so much?

http://groups.yahoo.com/group/OutdoorLighting-Forum/files/
Reference material on Outdoor Lighting – members only

http://groups.yahoo.com/group/OutdoorLighting-Forum/files/Articles%20and%20Papers/lp181a.pdf
A RATIONALE FOR THE MANDATORY LIMITATION OF OUTDOOR LIGHTING - members only

http://www.springer.com/dal/home/physics?SGWID=1-10100-22-36486016-0
Light Pollution Handbook Series: Astrophysics and Space Science Library , Vol. 322 , 267.50 Euros,
Narisada, Kohei; **Schreuder**, Duco 2004, XXVIII, 943 p., Hardcover, ISBN: 1-4020-2665-X
Constituting the first holistic overview including practical remedies, this handbook provides the background needed by anyone grappling with the complex issue of outdoor lighting and its effects. It describes not only the problems that astronomers and other night sky observers face in reducing the problems of information loss due to light pollution, as well as the problems lighting technologists face in optimising outdoor lighting installations that cause little or no light pollution. The first part is directed to decision makers and managers of outdoor space and covers the areas of general interest, culminating in recommendations to reduce the impact of light pollution. The second part is directed primarily to scientists and engineers, as a support to the design and maintenance of outdoor lighting installations, with special reference to astronomical observations. Elaborating issues from the first part, these contributions include examples that refer to specific outdoor lighting projects and to more general policy and educational measures.

http://www.nightwise.org/review.htm
Review of *Light Pollution Handbook*

http://icole.home.att.net/olprpt.pdf
Outdoor lighting practices in the state of Indiana

http://www.nightwise.org/nightvision.htm
Night Vision is a NASA-supported program in which observers quantify the sky glow over their community.

http://hometownlife.com/apps/pbcs.dll/article?AID=/20070315/NEWS11/703150792&SearchID=73275645912863
New lighting regulations loom for Milford businesses

http://www2a.biglobe.ne.jp/~wakaba/lp/taiwan-e.pdf
Light Pollution – Its Problem and Solution – IDA Japan Section

http://www2a.biglobe.ne.jp/~wakaba/lp/taiwan2-e.pdf
Light and Human – IDA Japan Section

http://www.globe.gov/GaN/analyze.html
Globe at Night

http://www.darksky.org/news/newsletters/60-69/nl66_fea.html
Sustainability, Urban Planning, and What They Mean to Dark Skies

http://www.energy.ca.gov/title24/
Title 24, Part 6 – California Energy Efficient Standards for Residential and Nonresidential Buildings
- makes use of lighting zones and says cutoff luminaires are more efficient
Example 6-14 - …residential parking lots for eight or more vehicles are required to meet the Nonresidential Standards, which do include cutoff requirements for luminaries greater than 175 watts. Even though not required for most residential outdoor lighting, cutoff luminaires are usually more efficient at providing light in the required area, so a lower wattage lamp and ballast can be used. Cutoff luminaires also reduce stray light and glare problems which can be a source of legal dispute between tenants or with neighbouring property owners.

http://www.nmheritage.org/files/NightSky_Friendly_Lighting_Guide2.pdf
Consumer Guide to Night Sky Friendly Lighting

http://www.nweurope.org/page/projetIdea.php?p=22&id=610
N°523 | NIGHT SKY PROTECTION

http://www.astrosurf.com/anpcn/congres/GENK_2005/programme.html
Dark-Sky Symposium 2005, April 29th - 30th (many excellent presentations)

http://www.astrosurf.com/anpcn/congres/GENK_2005/vandewalle/presentation.ppt
Concept of the Night of Darkness, results and how to organize it

http://www.astrosurf.com/anpcn/congres/GENK_2005/hanel/presentation2.ppt
The increase of light pollution in Germany documented on satellite data

http://www.astrosurf.com/anpcn/congres/GENK_2005/Demirdes/presentation.ppt
Practical evaluation in the design stage, of Obtrusive Light from Outdoor Lighting Installations

http://www.astrosurf.com/anpcn/congres/GENK_2005/vantichelen/presentation.ppt
Policy actions for monitoring evolution of light pollution and providing best practice information in the Flemish region of Belgium

http://www.astrosurf.com/anpcn/congres/GENK_2005/Schmidt/presentation1.ppt
Survey on the appreciation of illumination and darkness in the Netherlands

http://www.astrosurf.com/anpcn/congres/GENK_2005/disora/presentation.ppt
The fight against light-pollution in Italy - Regional laws -The example of town of Frosinone

http://www.astrosurf.com/anpcn/congres/GENK_2005/kindermans/presentation.ppt
Lighting of Golf Driving Ranges

http://www.astrosurf.com/anpcn/congres/GENK_2005/kollath/presentation.ppt
The first Hungarian light pollution conference

http://www.astrosurf.com/anpcn/congres/GENK_2005/meeting/DeclarationGenk.pdf
Declaration of GENK 2005

http://www.astronomy.com/asy/default.aspx?c=a&id=4192
Celebrate National Dark-Sky Week

http://www.astronomy.com/asy/default.aspx?c=a&id=3225
Quebec leads the charge against light pollution

http://www.bicomnet.com/ritchieobs/pages/lights.htm
Lights of Bainbridge Island

http://news.nationalgeographic.com/news/2004/03/0318_040319_travelwatch.html
Hotels Cut Light Pollution, See Stars

http://news.nationalgeographic.com/news/2006/05/dark-skies-1.html
Dark Skies Initiatives Aim to Boost Stargazing

http://www.volt.org/index.html
Virginia Outdoor Lighting Task Force (VOLT)

http://www.lightpollution.it/roadpollution/roadpaper1_turin.pdf
Light pollution by luminaires in roadway lighting

http://www.lightpollution.org.uk/dwnLoads/cfds_2006oct_AandG_proof.pdf
http://britastro.org/baa/content/view/168/2/
Dark Skies for All – Sixth European Dark-Skies Symposium, Sept 2006

http://www.savethenight.eu/Home.html
Save the Night in Europe

http://www.lightpollution.org/index.htm
Croation Dark Sky Association (in Croation)

http://www.preventielichthinder.be/
Belgian Dark Sky site (in Belgian)

http://news.bbc.co.uk/2/hi/uk_news/england/west_yorkshire/6033751.stm
£100m city lights project will reduce light pollution.

http://news.bbc.co.uk/2/hi/uk_news/england/norfolk/4475492.stm
Praise for polluting light cut

http://www.britastro.org/dark-skies/index.html
http://www.britastro.org/dark-skies/theproblems.html?7O
The British Astronomical Association's Campaign for Dark Skies (CfDS)
The Issues surrounding lighting:

- Disappearing stars
- Security
- Medical Health Problems
- Life Threatening Dangers
- The Environmental Cost
- The Economic Cost
- The Threat to wildlife
- The Disturbance to Neighbours
- For Our Children...

http://www.bbc.co.uk/insideout/northeast/series7/light_pollution.shtml
http://www.bbc.co.uk/cumbria/weather/sky_at_night/light_pollution.shtml
http://www.bbc.co.uk/wiltshire/weather/light_polution.shtml
http://news.bbc.co.uk/2/hi/uk_news/england/humber/3248895.stm
http://news.bbc.co.uk/2/hi/europe/3178272.stm
http://news.bbc.co.uk/2/hi/uk_news/politics/3167276.stm
http://news.bbc.co.uk/2/hi/uk_news/england/devon/3011170.stm
http://news.bbc.co.uk/2/hi/science/nature/4794249.stm
Light pollution is getting worse in the UK

http://www.communities.gov.uk/index.asp?id=1144844
Lighting in the Countryside: Towards Good Practice

http://www.communities.gov.uk/pub/827/Figure61Assessmentoflighting_id1144827.pdf
Assessment of Lighting

http://www2.nature.nps.gov/air/lightscapes/
Natural lightscapes, How is light pollution measured? - Better Lighting

OUTDOOR LIGHTING AND CRIME

http://amper.ped.muni.cz/light/crime/
Outdoor lighting and crime - At the end of the directory list is a summary.

http://www.celfosc.org/biblio/seguridad/atkins.pdf
THE INFLUENCE OF STREET LIGHTING ON CRIME AND FEAR OF CRIME
The principal conclusion is that no evidence could be found to support the hypothesis that improved street lighting reduces reported crime.

http://www.homeoffice.gov.uk/rds/prgpdfs/fcpu29.pdf
THE EFFECT OF BETTER STREET LIGHTING ON CRIME AND FEAR: A REVIEW
There is clearer evidence that improved street lighting can help to reduce ***fear*** of crime, at least among some people, or in relation to certain specific places, than there is of any consistent impact on crime itself.

http://amper.ped.muni.cz/light/crime/lp040_1.pdf
OUTDOOR LIGHTING AND CRIME, PART 1: LITTLE OR NO BENEFIT

http://amper.ped.muni.cz/light/crime/OLCpt2.pdf
OUTDOOR LIGHTING AND CRIME, PART 2: COUPLED GROWTH

http://bjc.oxfordjournals.org/cgi/content/abstract/44/3/441
A Demonstration That the Claim That Brighter Lighting Reduces Crime Is Unfounded

http://asumag.com/mag/university_lighting_deterrent_crime/
Deterrent to crime.

http://ile.org.uk/uploads/File/News/LightPollConfFlyer.pdf
Light Pollution – Managing the Impacts

http://www.insitiuteoflightingengineers.webserverworld.co.uk/uploads/File/01_lightpollution.pdf
Light Pollution and New Legislation

http://www.insitiuteoflightingengineers.webserverworld.co.uk/uploads/File/03_securitylighting.pdf
Domestic Security Lighting, Friend or Foe

http://www.insitiuteoflightingengineers.webserverworld.co.uk/uploads/File/06_illuminatedads.pdf
Brightness of Illuminated Advertisements

http://www.montgomerycountymd.gov/content/dep/energy/light/Light%20Pollution.ppt
Outdoor Lighting: Approaches Taken by State and Local Governments (**excellent** presentation)

More Light Pollution LINKS

http://www.elights.com/lightinglinks.html#darksky
Friendly Sky Information, Lighting Organizations, Lighting Calculations, Lighting Standards, Lighting Directory Resources

http://www.rscc.cc.tn.us/obs/Dark%20Skies%20Materials.htm
Protecting our dark and starry skies -- help us at TAO save our beautiful local night sky!

http://www.google.ca/search?hl=en&q=%22light+pollution%22+OR+%22obtrusive+light%22+OR+%22light+trespass%22+OR+%22nuisance+light%22+OR+%22dark+sky%22&btnG=Search&meta=
Links for Light Pollution in Google in English

http://dynamics.org/Altenberg/PROJECTS/STARRY_NIGHTS/LiteLynx.html
Light Pollution Internet Links

http://www.google.fr/search?q=%22pollution+lumineuse%22+OR+%22pollutions+lumineuses%22
Links for Light Pollution in Google in French

http://www.google.fi/search?hl=fi&sa=X&oi=spell&resnum=0&ct=result&cd=1&q=%22valosaaste%22&spell=1
Links for Light Pollution in Google in Finnish

http://seula.net/seula_valosaaste.htm
Finnish dark sky site

http://www.finlex.fi/fi/laki/ajantasa/2000/20000086
Finnish nuisance law

An addition source of references is:
http://directory.google.com/Top/Society/Issues/Environment/Light_Pollution

http://www.asv.org.au/index.php?option=com_content&task=view&id=33&Itemid=76
Unnecessary light pollution is blotting out the night sky

http://www.lightsearch.com/search/international/australia/dwnunder.html
Down under Lighting

http://www.crlaction.org
Citizens for responsible lighting

http://www.njaa.org/light.html
Light pollution

http://cfa-www.harvard.edu/cfa/ps/nelpag.html
New England Light Pollution Advisory Group (NELPAG)

http://amper.ped.muni.cz/light/ctstarwchr/LiteLynx.htm
Light Pollution Internet Links

http://www.rocketroberts.com/astro/litepol.htm
Light Pollution - The Bane of Astronomers

http://www.nwanews.com/adg/News/147682/print/
Cities balk at price of new streetlights

Definitions

http://www.electro-optical.com -> Education/Refs -> Candela
Definitions: of candela, lumen, lux

http://physics.nist.gov/cuu/Units/units.html

Unit of luminous intensity **candela** The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

Derived units

luminance			candela per square meter	cd/m^2
illuminance	lux	lx	lm/m^2	$m^2 \cdot m^{-4} \cdot cd = m^{-2} \cdot cd$
luminous flux	lumen	lm	$cd \cdot sr$ (c)	$m^2 \cdot m^{-2} \cdot cd = cd$
solid angle	steradian (a)	sr (c)	-	$m^2 \cdot m^{-2} = 1$ (b)

(c) In photometry, the unit name steradian and the unit symbol sr are usually retained in expressions for derived units.
A uniform point source of 1 candle emits 4 pi lumens = 12.5666637061436 lumens

http://www.schorsch.com/kbase/glossary/illuminance.html Typical Illuminance levels

Typical illuminance values are:

1 lx	full moon
10 lx	street lighting
100-1'000 lx	workspace lighting
10'000 lx	surgery lighting
100'000 lx	plain sunshine

http://www.schorsch.com/kbase/glossary/luminance.html

The physical measure of *brightness*.
Luminous intensity per unit projected area of any surface, as measured from a specific direction.

Luminance (usually 'L' in formulas) is the amount of visible *light* leaving a point on a surface in a given direction. This "surface" can be a physical surface or an imaginary plane, and the light leaving the surface can be due to reflection, transmission, and/or emission
Standard unit of luminance is **candela per square meter (cd/m^2)**.
It is also called **Nits** in the USA, from latin "nitere" = "to shine"

Typical luminance values are:

1.6 * 10^9 cd/m^2	Solar disk at noon (don't look!)
600'000 cd/m^2	Solar disk at horizon
120'000 cd/m^2	Frosted bulb 60 W
11'000 cd/m^2	T8 cool white fluorescent
8'000 cd/m^2	Average clear sky
2'500 cd/m^2	Moon surface
2'000 cd/m^2	Average cloudy sky
30 cd/m^2	Green electroluminescent source
0.0004 cd/m^2	Darkest sky

http://www.lightmeasurement.com/
For the visible part of the spectrum (380nm - 780nm) a separate set of parameters is defined. These photometric values derive from the radiometric quantities by weighting them with the spectral response function for intensity of the human eye.

- Luminous Flux [lm]
- Luminous Intensity [lm/sr = cd]
- Illuminance [lm/m² = lx]
- Luminance [cd/m²]

http://ergo.human.cornell.edu/studentdownloads/DEA350notes/Lighting/lightingnotes1.html

Observed Luminance

When a part of the incident light striking a surface is reflected the human eye will observe that surface as a light source. The brightness observed is called the luminance, L, and is defined as intensity per unit apparent area of light source. The apparent area, A', is the area the source seems to have as seen by the observer. Thus, L = Iu / A' where A' tends to 0.

For a plane surface the apparent area can be found from the equation: A' = A x cos u, where A is the actual area of the source, and u the angle between the normal to the surface and the direction of observation. Iu is the luminous intensity in that direction.

Alternatively, the luminance of a surface can be calculated from the formula L = E x § / ¹ where § is the luminance factor of the surface material and is read from a table of values. If the surface is diffuse then § can be replaced with "p", the diffuse reflection coefficient for the material. A typical luminance for a piece of white paper under an illuminance of 500 lux is thus 130 cd/m^2.

The eye can detect luminances from as little as one millionth of a cd/m2 up to a maximum of one million cd/m^2. The upper limit is determined by the luminance required to damage the retina. The reason that our eyes are so easily damaged by looking at the sun is explained when we see that its luminance is 1000 times greater than this maximum level.

Photometric Quantities:

- **Radiant flux** is usually measured in watts.
- **Luminous flux** - the fundamental quantity measuring the rate of flow of radiant energy modified for its effectiveness in creating the sensation of seeing i.e. Luminous flux = radiant flux x relevant spectral sensitivity of visual system. In SI units, luminous flux is measured in
    - **lumens (lm)**. Luminous flux is useful for describing the total light output of light sources. However, to describe the distribution of light from a source, **luminous intensity** is used.
- **Luminous intensity** - the luminous flux emitted per unit solid angle in a specified direction. The measure is the
    - **candela (cd)** which is equivalent to the lumens per steradian (lumens steradian - 1). Formally the candela is defined as "the luminous intensity in a given direction of a source emitting monochromatic radiation at 555 nm of which the radiant intensity is 1/683 watts steradian^-1." Both these have AREA measures associated with them.
- I**lluminance** - the luminous flux per unit projected area of a surface in a given direction (luminous flux/unit solid angle/unit area) measured in
    - **candela per meter^2 (cd/m^2)** (1 footlambert = 3.43 candela/m^2)

Luminance/ Reflectance/ Apostilbs

With a non-luminous surface e.g., a wall, what the eye sees - the brightness or luminance of the surface - depends on the **reflectance** i.e. the ratio of reflected light to incident light. With an illuminance of 500 lux and a reflectance of 0.4 the luminance of the surface will be 200 apostilbs.

- Illuminance (lux) x reflectance = luminance (apostilbs).
- Apostilbs is not an SI unit. To convert this to SI (candelas/ m^2) divide by pi (or multiply by 0.318).
- If the Munsell "Value" reference of a color is known the reflectance can be approximately calculated using Reflectance = V(V - 1) where V = value.
- If Munsell "value" is 6, reflectance = 6 x 5 = 30% = .3.
- Since in most rooms the different surfaces will have different colors, they will reflect differing amounts of light and this will affect the distribution of light in the room.

Reflectance

- For a perfectly diffusely reflecting surface, the ratio of the reflected luminous flux to the incident luminous flux is the reflectance.
- Luminance = illuminance x reflectance / pi
- Reflectance = illuminance / luminance
- When the surface is not perfectly diffusely reflecting, reflectance is replaced by a

  luminance factor

  Luminance factor is the ratio of the luminance of a surface viewed from a particular position and lit in a specified way to the luminance of a diffusely reflecting white surface viewed from the same direction and lit in the same way. Here Luminance = illuminance x luminance factor / pi.

http://en.wikipedia.org/wiki/Luminance

Luminance (also called *luminosity*) is a photometric measure of the density of luminous intensity in a given direction. It describes the amount of light that passes through or is emitted from a particular area, and falls within a given solid angle. The SI unit for luminosity is candela per square meter (cd/m^2).

Luminance is often used to characterize emission or reflection from flat, diffuse surfaces. The luminance indicates how much luminous power will be perceived by an eye looking at the surface from a particular angle of view. Luminance is thus an indicator of how bright the surface will appear. In this case, the solid angle of interest is the solid angle subtended by the eye's pupil. Luminance is used in the video industry to characterize the brightness of displays. In this industry, one candela per square meter is commonly called a "nit". A typical computer display emits between 50 and 300 nits.

Luminance is invariant in geometric optics. This means that for an ideal optical system, the luminance at the output is the same as the input luminance. For real, passive, optical systems, the output luminance is *at most* equal to the input. As an example, if you form a demagnified image with a lens, the luminous power is concentrated into a smaller area, meaning that the illuminance is higher at the image. The light at the image plane, however, fills a larger solid angle so the luminance comes out to be the same assuming there is no loss at the lens. The image can never be "brighter" than the source.

SI photometry units				
				edit
Quantity	**Symbol**	**SI unit**	**Abbr.**	**Notes**
Luminous energy	Q_v	lumen second	lm·s	units are sometimes called Talbots
Luminous flux	F	lumen (= cd·sr)	lm	also called luminous power
Luminous intensity	I_v	candela (= lm/sr)	cd	
Luminance	L_v	candela / square metre	cd/m^2	also called ***luminosity***
Illuminance	E_v	lux (= lm/m^2)	lx	Used for light incident on a surface
Luminous emittance	M_v	lux (= lm/m^2)	lx	Used for light emitted from a surface
Luminous efficacy		lumens / watt	lm/W	ratio of luminous flux to radiant flux, maximum possible is 683

http://www.stjarnhimlen.se/comp/radfaq.html
Radiometry and photometry in astronomy

http://www.lashen.com/vendors/pelco/Typical_Light_Levels.asp
Typical lux levels day and night

http://www.sunshinesales.ca/table.html
Table of lux levels in our environment

Standards and Technical Reports

CIE S 016/E:2005, Lighting of Outdoor Work Places
- Lighting Requirements for Safety and Security

CIE S 015/E:2005, Lighting of Outdoor Work Places

CIE 126 – 1997 Tech. Report. – Guidelines for Minimizing Sky Glow, ISBN 3 900 734 83 6

CIE 150:2003 Tech. Report. – Guide On the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations

CIE 112 – 1994, Tech. Report. - Glare Evaluation System fro Use within Outdoor Sports and Area Lighting

http://www.techstreet.com/cgi-bin/browsePublisher?publisher_id=60
Source CIE standards documents and reports

IESNA TM-11-2000, Technical Memorandum on Light Trespass: Research, Results and Recommendations, ISBN #0-87995-174-5

IESNA TM-10-00, Technical Memorandum Addressing Obtrusive Light (Urban sky Glow and Light Trespass) in Conjunctions with Roadway Lighting, ISBN # 0-87995-172-9

IESNA RP-33-99, Lighting for Exterior Environments - is a publication that addresses community responsive design. 1999

http://www.insitiuteoflightingengineers.webserverworld.co.uk/uploads/File/02_lightreduction.pdf
GUIDANCE NOTES FOR THE REDUCTION OF OBTRUSIVE LIGHT

http://www.ile.org.uk/index.php?page=pollution
Guidance Notes from the Institution of Lighting Engineers in the UK