



A call for urban lighting governance

in the vicinity of protected areas

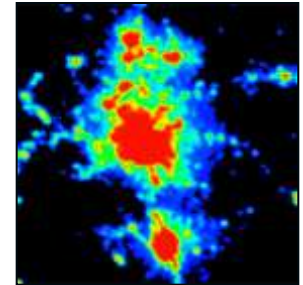


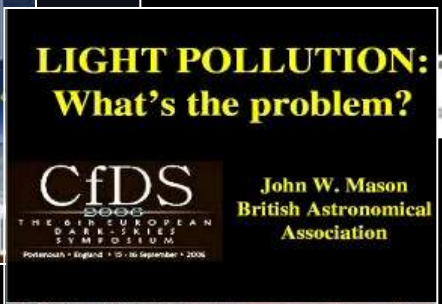
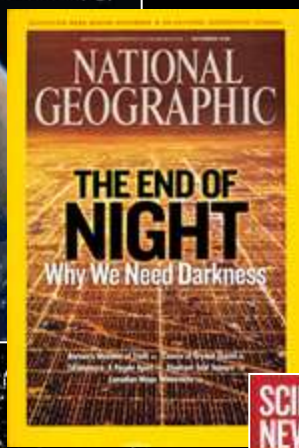
C. Aubrecht, M. Jaiteh, A. de Sherbinin, T. Longcore, C.D. Elvidge

BiodiverCities 2010 | An International Conference of the Urban Protected Areas Network
Paris, France | September 7, 2010

Outline

- Light pollution impact on ecosystems
 - Related work
 - Coral reefs, sea turtles, sea birds
- Satellite based nighttime Earth Observation
 - NOAA-NGDC: **D**efense **M**eteorological **S**atellite **P**rogram
- **Protected area exposure to artificial night lighting**
 - Status of protected areas worldwide
 - World Database on PAs (WDPA), Terrestrial Biomes
 - Protected Area Lighting Impact Indicator
 - Data issues, shortcomings, and future possibilities
 - WDPA, Nighttime lights
- Call for **Urban Lighting Governance**
 - Legal implementation
 - Possible effects





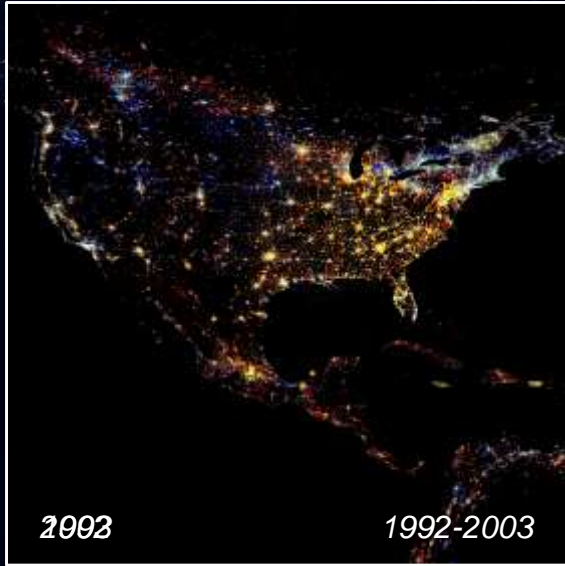
2003

1992-2003



2003

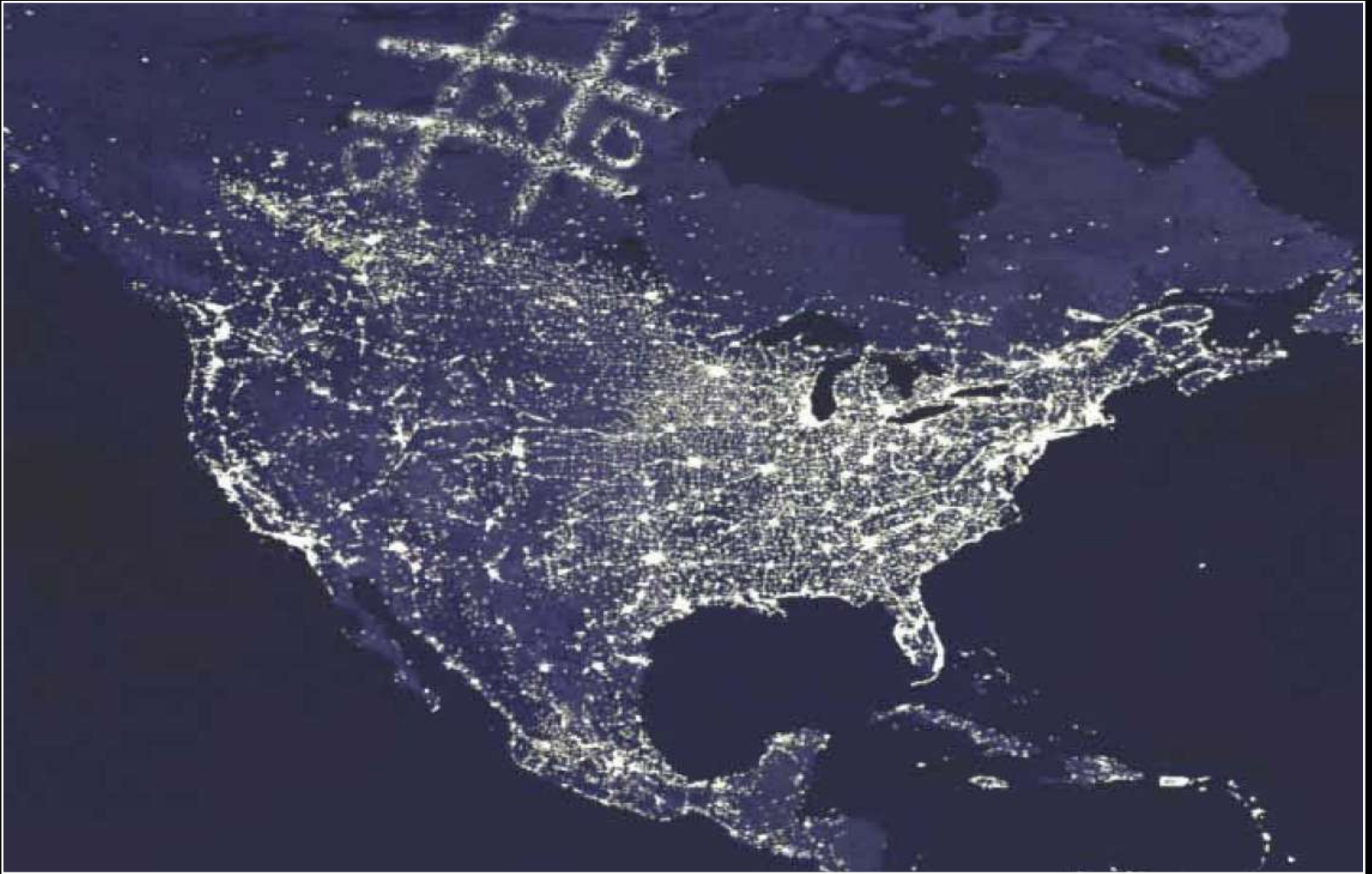
1992-2003



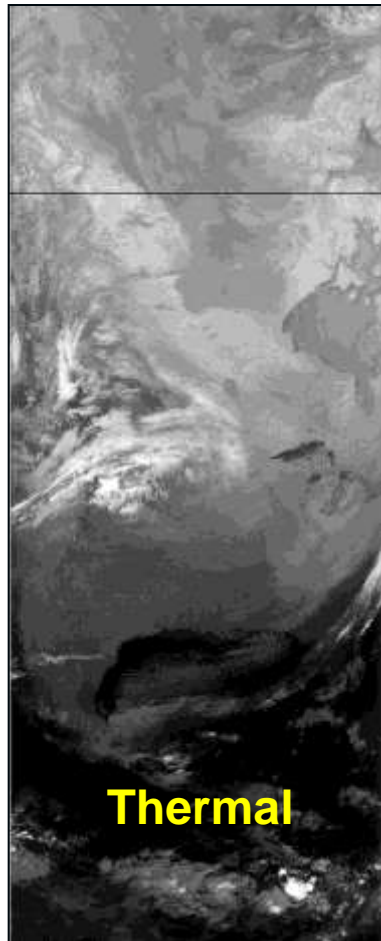
... 20,000 years ago ...

... 20,000 years ago ...

Nighttime lights showing alien activity on Earth? ...



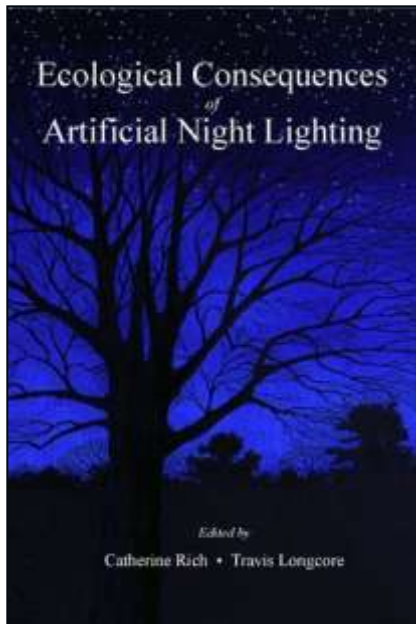
Artificial night lighting as seen from space



- The U.S. Air Force **Defense Meteorological Satellite Program (DMSP)** Operational Linescan System (OLS) has a unique capability to collect low-light imagery
 - Polar orbiting
 - 3,000 km swath
 - Two spectral bands
 - Visible and thermal
 - Nightly global coverage
 - Flown since 1972
 - Will continue till ~2012

Ecological impact of artificial night lighting

- Nocturnal lighting can have direct effects on ecosystems
 - Rich, C., T. Longcore (2006) *Ecological Consequences of Artificial Night Lighting*. Washington D.C.: Island Press.



Selected chapters:

- Effects of artificial night lighting on migrating **birds**
[Gauthreaux Jr. & Belser]
- Influences of artificial light on **marine birds**
[Montevecchi]
- Threatened **sea turtle** nesting sites
[Salmon]
- **Fish** response to artificial night lighting
[Nightingale et al.]

Ecological impact of artificial night lighting

- Related work - selected applications:

1. **Coral reefs** - Lights Proximity Index (LPI)

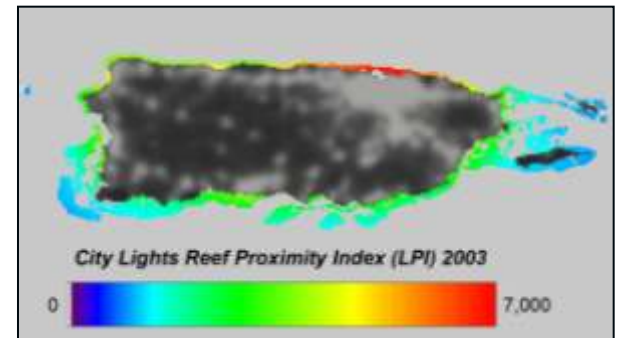
- Global and regional scale
- Temporal trends

2. **Sea turtles** - Florida

- Nesting activity and artificial night lighting

3. **Sea birds** - Azores

- Rescue campaigns (bird falling)
- Comparison of satellite data and ground collection records

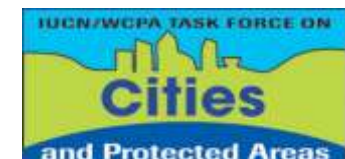


Ecological impact of artificial night lighting



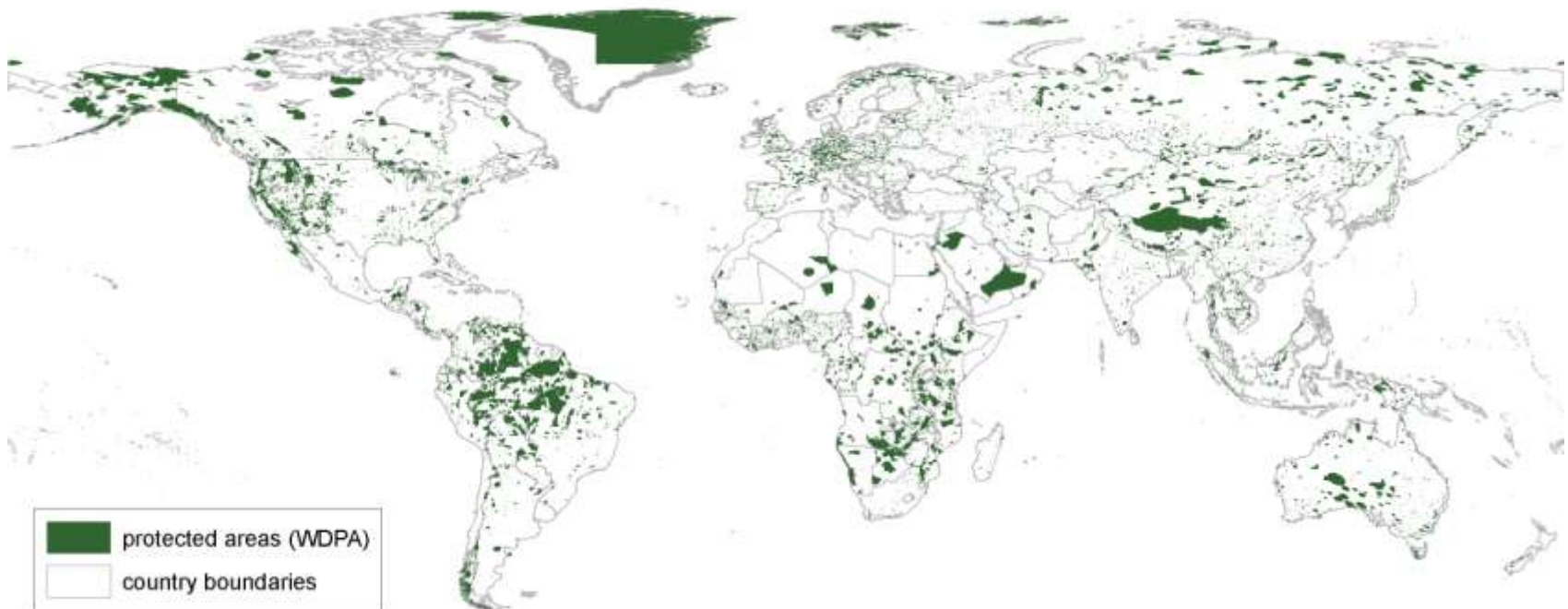
- Aubrecht, C., M. Jaiteh, A. de Sherbinin (2010) *Global assessment of light pollution impact on protected areas*. CIESIN/AIT Working Paper. Center for International Earth Science Information Network, The Earth Institute at Columbia University. Palisades, NY, USA. *Journal paper in preparation (Global Ecology and Biogeography, Wiley)*.

Set up of 'Dark Skies Advisory Group' in early 2009



Data on Protected Areas

- World Database on Protected Areas (WDPA)
 - **UNEP-WCMC** – 12/2007 version (compiling information since 1981)
 - Collaboration with **IUCN**'s World Commission on PAs (**WCPA**)



Data on Protected Areas

- World Database on Protected Areas (WDPA)
 - **UNEP-WCMC** – 12/2007 version (compiling information since 1981)
 - Collaboration with **IUCN**'s World Commission on PAs (**WCPA**)
- Focus on terrestrial areas
 - Marine Protected Areas excluded
 - Historical, archaeological, cultural site listings excluded
 - Proposed, but not yet designated sites excluded
 - Designated 'international' PAs excluded
 - Most of these areas (e.g. World Heritage, Ramsar, Biosphere Reserve sites) are additionally contained in some category featuring protection on national level
 - Without having such **national legal status**, PAs cannot be considered to be adequately protected

Data on Protected Areas

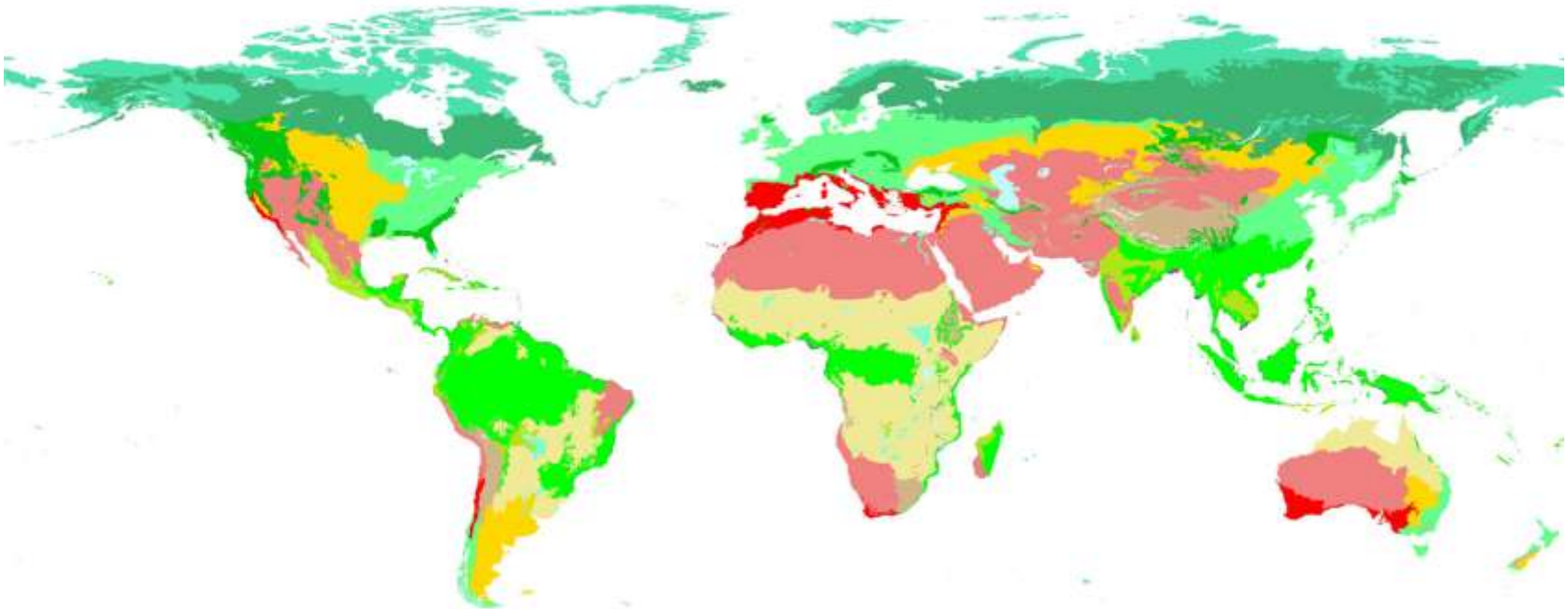
- World Database on Protected Areas (WDPA)
 - **UNEP-WCMC** – 12/2007 version (compiling information since 1981)
 - Collaboration with **IUCN**'s World Commission on PAs (**WCPA**)
- Data provided online for download as GIS shapefiles
 - Polygon features
 - Point features
 - **Center point locations** for PAs where area boundaries have not been mapped or boundary files are not available
 - Information provided on the **total PA extent** [ha] as defined in governmental declarations/decrees or management plans → creation of a spatial approximation (buffering)
 - Conversion to raster format for consistent computation

‘Background’ data

- Administrative data – country boundaries
 - From GRUMP/GPW
- Terrestrial biomes
 - Obtained from WWF’s **Terrestrial Ecoregions of the World** (Olsen et al. 2001)
 - Biomes → aggregation of correlated ecoregions

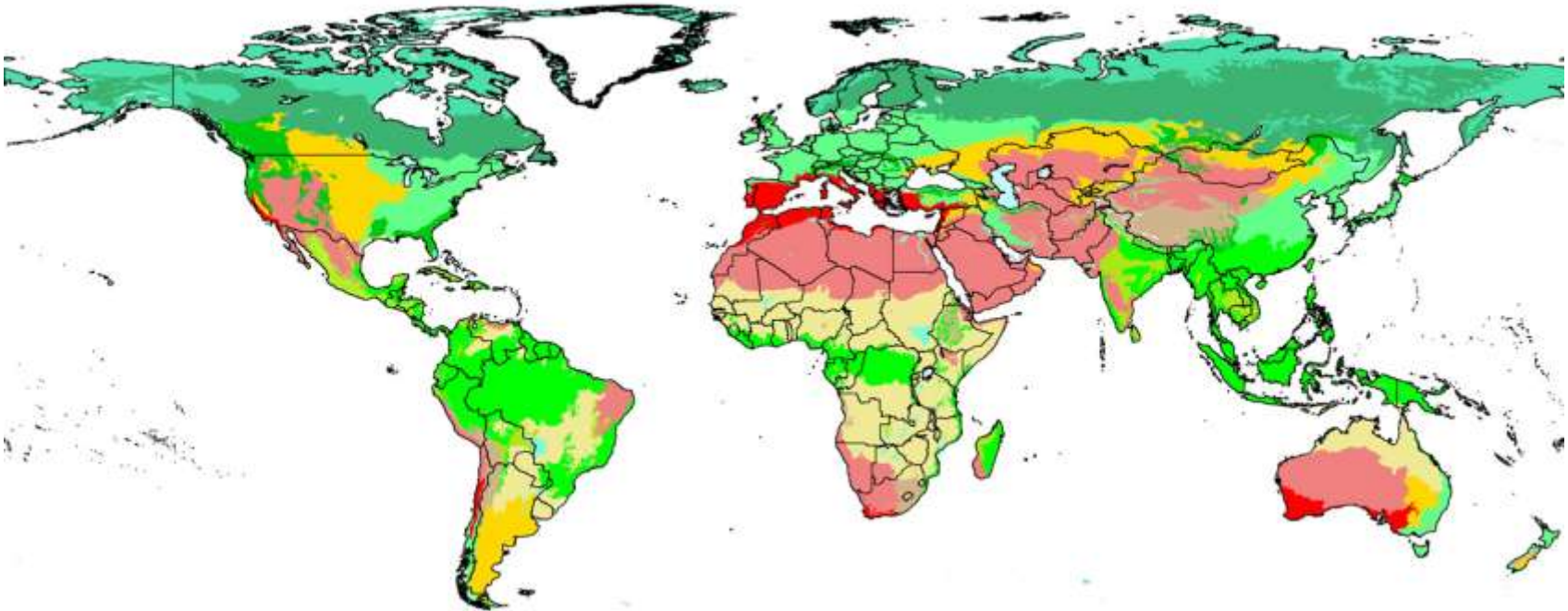
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







'Background' data









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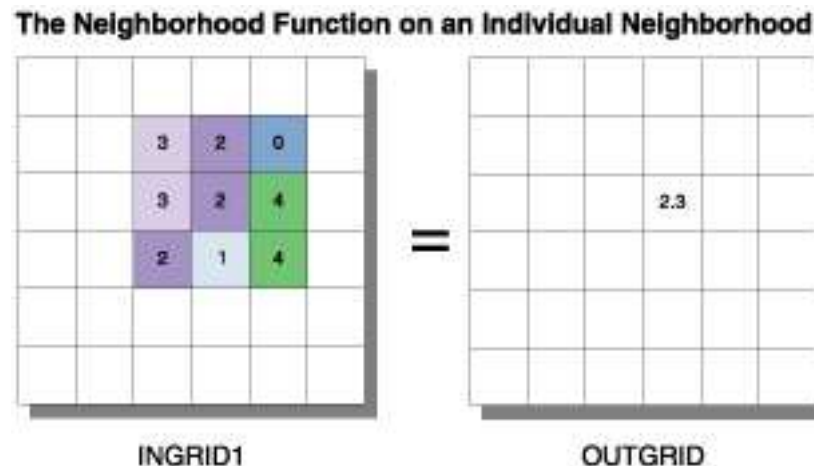
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 - Biomes → aggregation of correlated ecoregions
 -  Tropical and Subtropical Moist Broadleaf Forests (15.2%)
 -  Tropical and Subtropical Dry Broadleaf Forests (2.3%)
 -  Tropical and Subtropical Coniferous Forests (0.5%)
 -  Temperate Broadleaf and Mixed Forests (9.7%)
 -  Temperate Coniferous Forests (3.1%)
 -  Boreal Forests/Taiga (11.2%)
 -  Tropical and Subtropical Grasslands, Savannas, and Shrublands (15.5%)
 -  Temperate Grasslands, Savannas, and Shrublands (7.7%)

'Background' data

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 -  Flooded Grasslands and Savannas (0.8%)
 -  Montane Grasslands and Shrublands (3.8%)
 -  Tundra (6.0%)
 -  Mediterranean Forests, Woodlands, and Scrub (2.5%)
 -  Deserts and Xeric Shrublands (21.4%)
 -  Mangroves (0.2%)
 -  Lakes (0.0%)
 -  Rock and Ice (0.2%)

Methodology

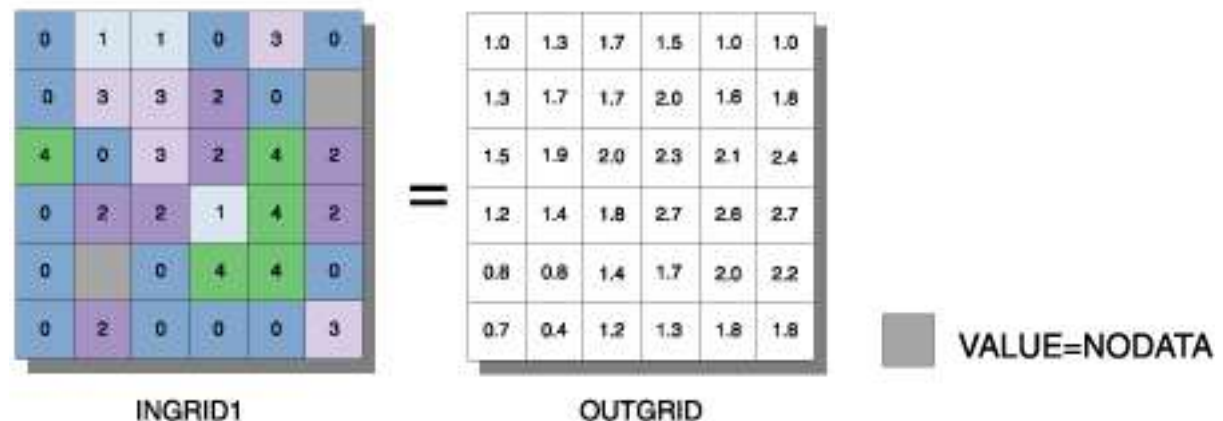
- **Direct impact** of artificial night lighting on PAs
 - Direct spatial overlap of lights (DMSP-OLS) and PAs (WDPA)
- Artificial night lighting as a **proxy measure for human impact** on PAs
 - Additional consideration of the immediate vicinity of lighting sources
 - Focal neighborhood function (5px radius ~ 5km)



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The Neighborhood Function on a Grid



Expression: FOCALMEAN(INGRID1, RECTANGLE, 3, 3)

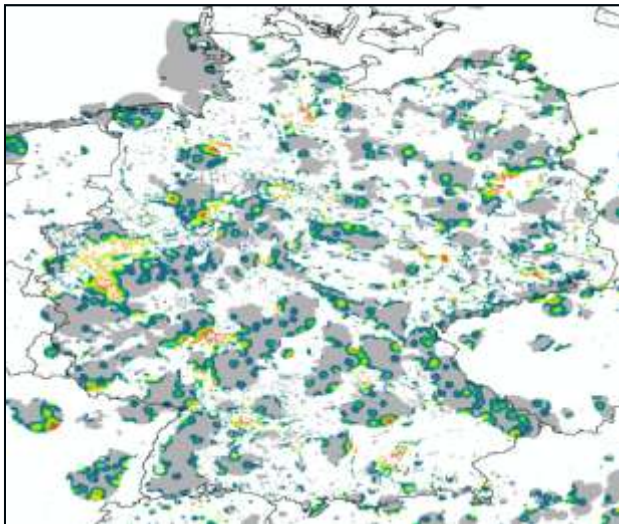
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Calculated indicators

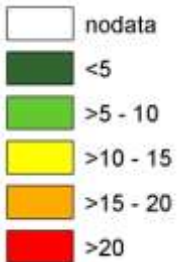
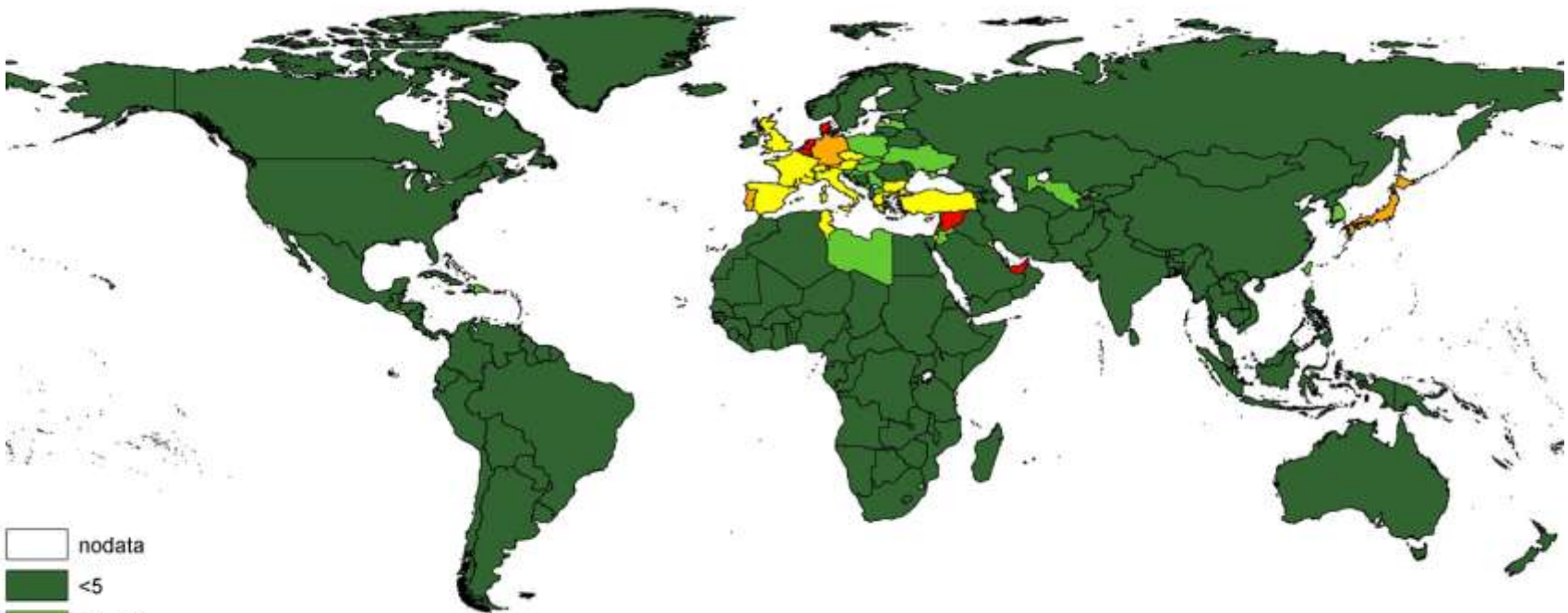
- Protected Area Index (**PAI**) / Eco-Region Protection Indicator (**ERPI**)
 - Percentage of PA (per country) / Percentage of PA (per biome, per country)
- Lighting Impact Indicator (**LI**)
 - Percentage of area affected by light pollution (per biome, per country)
- Human Impact Indicator (**HI**)
 - Percentage of area affected by human influence (per biome, per country)
- **Protected Area Lighting Impact Indicator (PALI)**
 - Percentage of PA affected by light pollution (per biome, per country)
- **Protected Area Human Impact Indicator (PAHI)**
 - Percentage of PA affected by human influence (per biome, per country)

All indicators – Global scale, biomes

Reference	Description	PAI ⁹ /ERPI ⁹ [%]	LI ⁹ [%]	HI ⁹ [%]	PALI ⁹ [%]	PAHI ⁹ [%]
World*	–	12.7	4.0	10.1	1.8	8.6
Biome 1	Tropical and Subtropical Moist Broadleaf Forests	20.6	1.8	8.5	0.8	3.4
Biome 2	Tropical and Subtropical Dry Broadleaf Forests	8.0	5.4	19.9	2.9	12.1
Biome 3	Tropical and Subtropical Coniferous Forests	6.9	3.7	14.1	3.0	16.2
Biome 4	Temperate Broadleaf and Mixed Forests	11.0	18.7	31.0	8.6	44.2
Biome 5	Temperate Coniferous Forests	24.7	7.5	17.6	3.1	16.9
Biome 6	Boreal Forests/Taiga	8.9	1.8	4.6	0.6	4.2
Biome 7	Tropical and Subtropical Grasslands, Savannas, and Shrublands	12.5	0.5	3.0	0.5	2.2
Biome 8	Temperate Grasslands, Savannas, and Shrublands	3.7	6.1	17.9	3.9	20.8
Biome 9	Flooded Grasslands and Savannas	19.2	5.0	10.1	1.1	5.0
Biome 10	Montane Grasslands and Shrublands	24.9	1.1	4.7	0.2	1.2
Biome 11	Tundra	16.7	0.4	1.0	0.2	1.4
Biome 12	Mediterranean Forests, Woodlands, and Scrub	6.9	10.7	28.3	8.8	34.8
Biome 13	Deserts and Xeric Shrublands	9.2	2.0	6.1	1.4	5.7
Biome 14	Mangroves	20.0	8.1	17.5	4.2	14.3
Biome 98	Lakes	24.1	5.4	12.5	3.2	33.1
Biome 99	Rock and Ice	29.9	0.0	0.2	0.1	1.1

⁹ This table shows the global values of PALI and PAHI

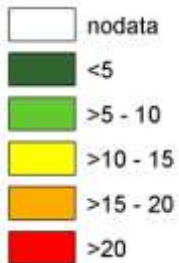
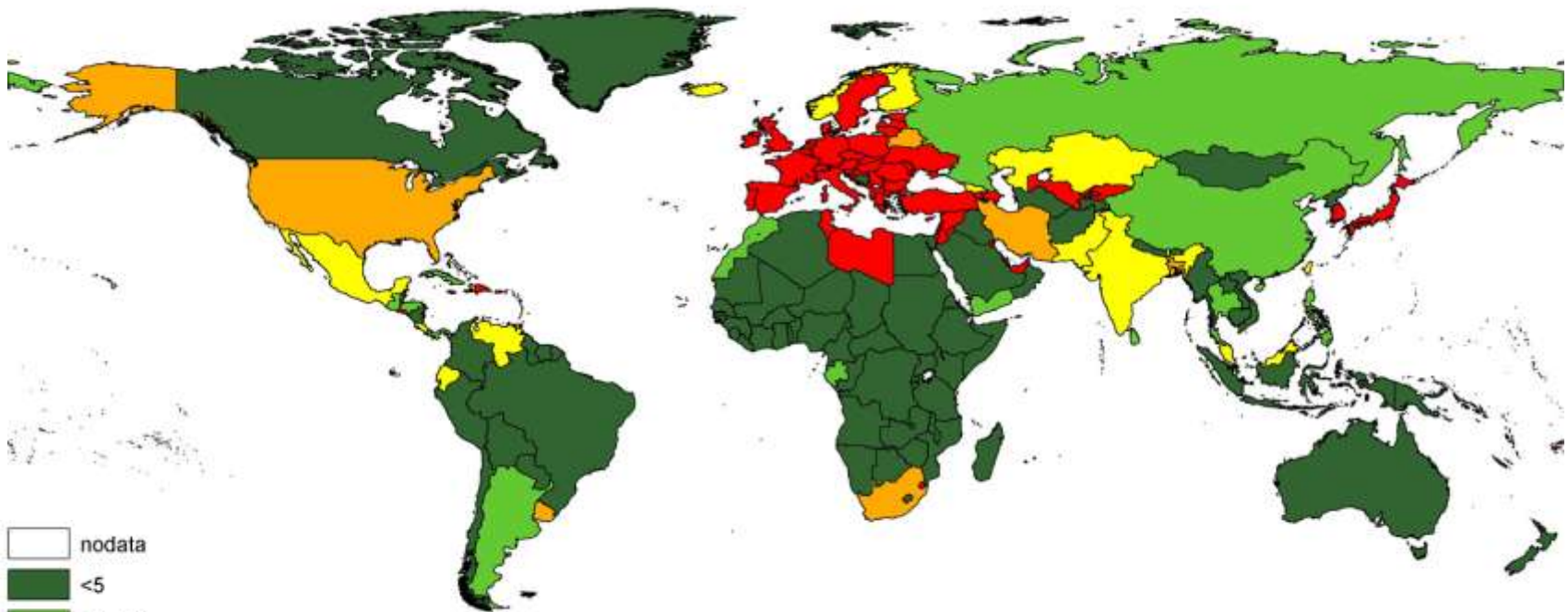
PALI⁹ / PAHI⁹ – Global scale, countries



Selected countries:

Equat. Guinea – 0.0%	Martinique – 97.8%
Cambodia – 0.0%	Puerto Rico – 60.9%
Norway – 0.5%	Syria – 40.4%
Saudi Arabia – 1.0%	France – 14.6%
USA – 3.4%	Austria – 10.2%

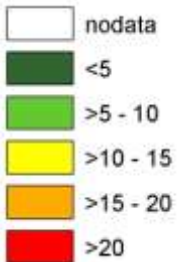
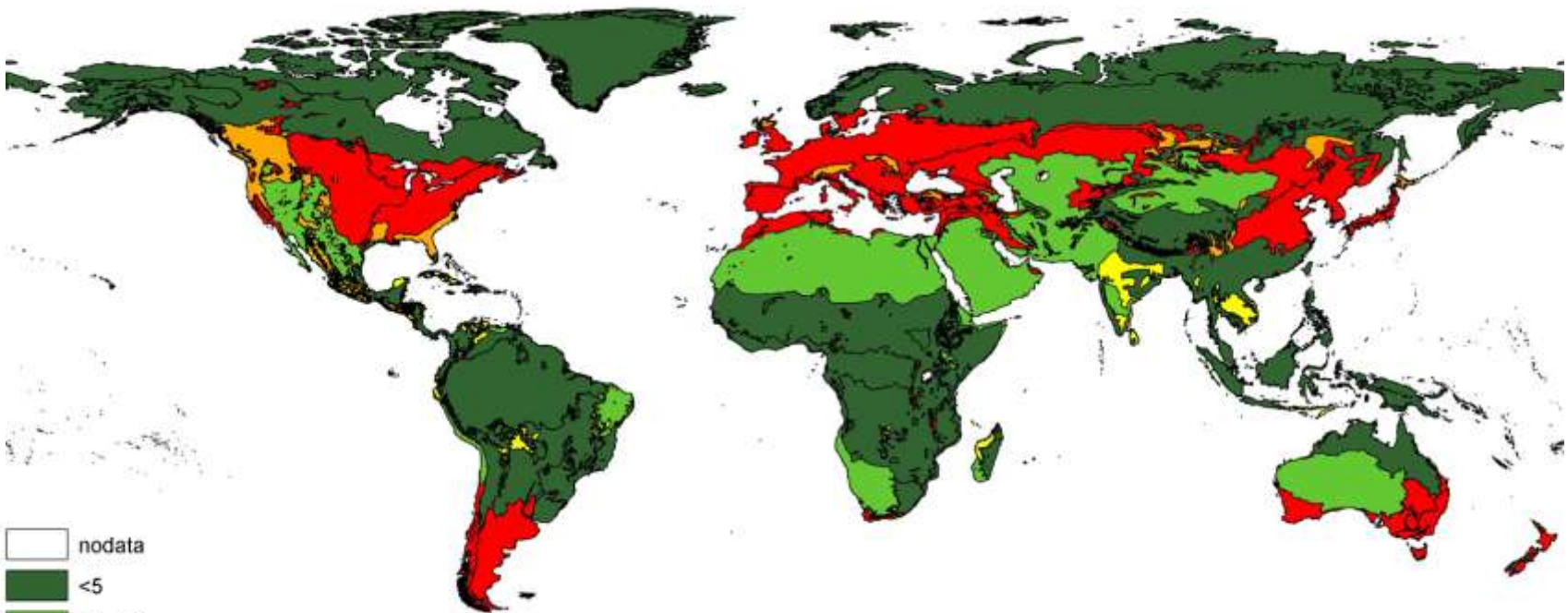
PALI⁹ / PAHI⁹ – Global scale, countries



Selected countries:

Equat. Guinea – 0.0%	Martinique – 100.0%
Cambodia – 0.2%	Puerto Rico – 100.0%
Norway – 10.6%	Syria – 100.0%
Saudi Arabia – 3.4%	France – 74.0%
USA – 16.8%	Austria – 57.7%

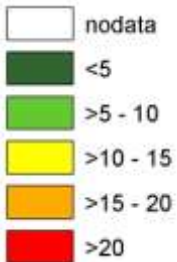
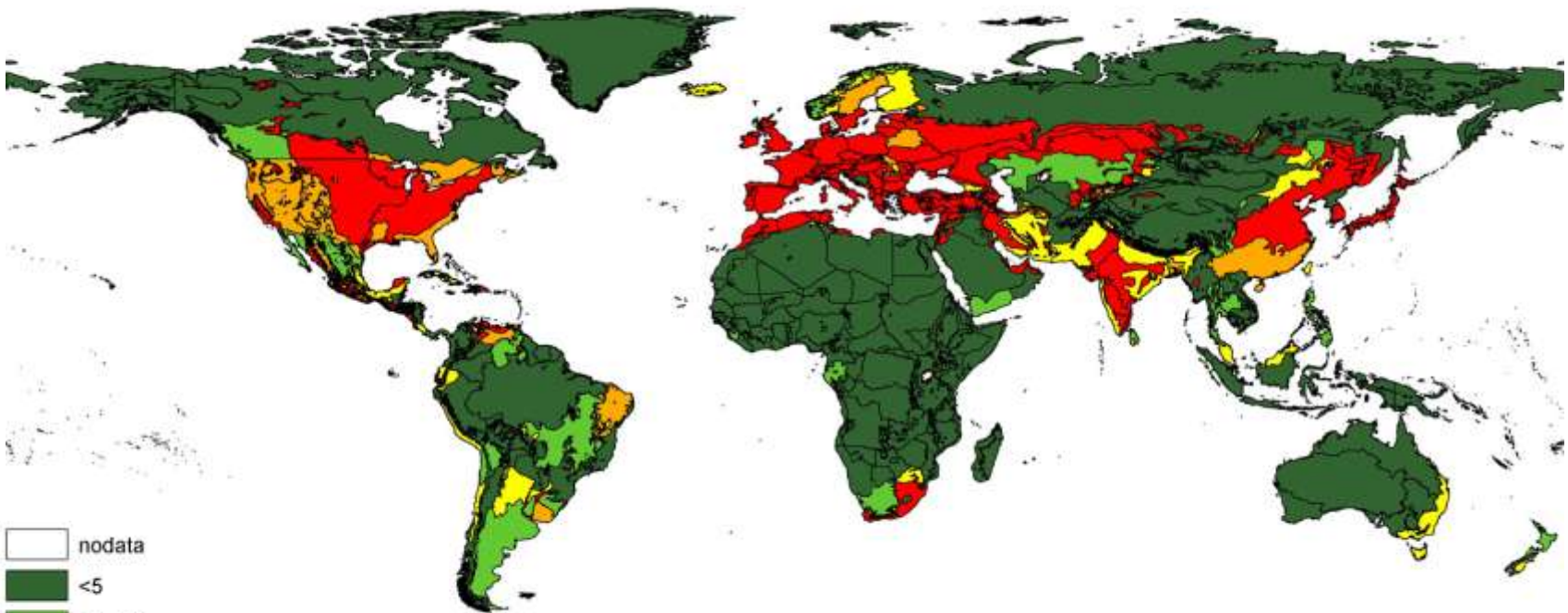
PALI⁹ / PAHI⁹ – Global scale, biomes



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PALI⁹ / PAHI⁹ – Global scale, biomes + countries

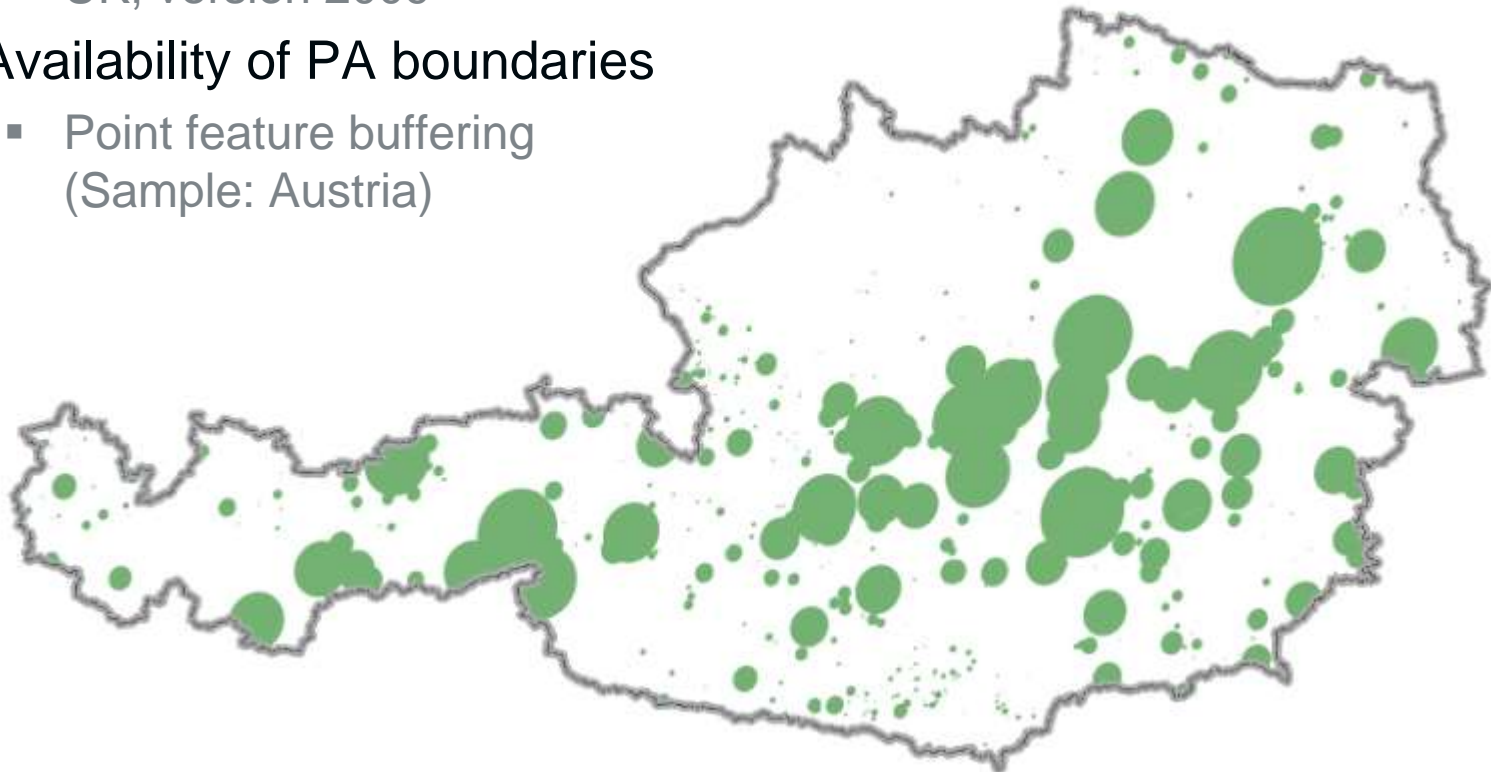


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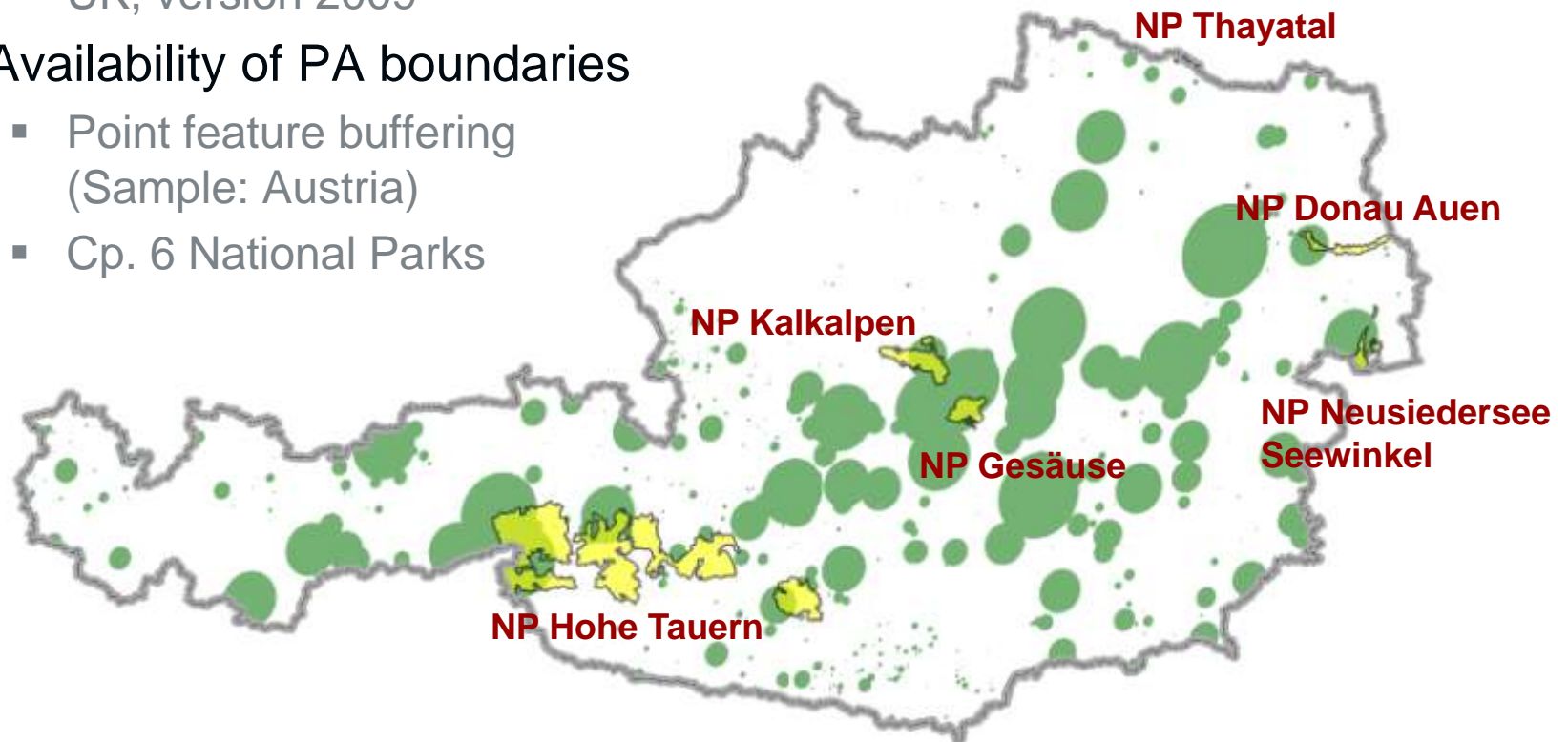
WDPA data issues

- General availability of PA data
 - UK, version 2009
- Availability of PA boundaries
 - Point feature buffering
(Sample: Austria)

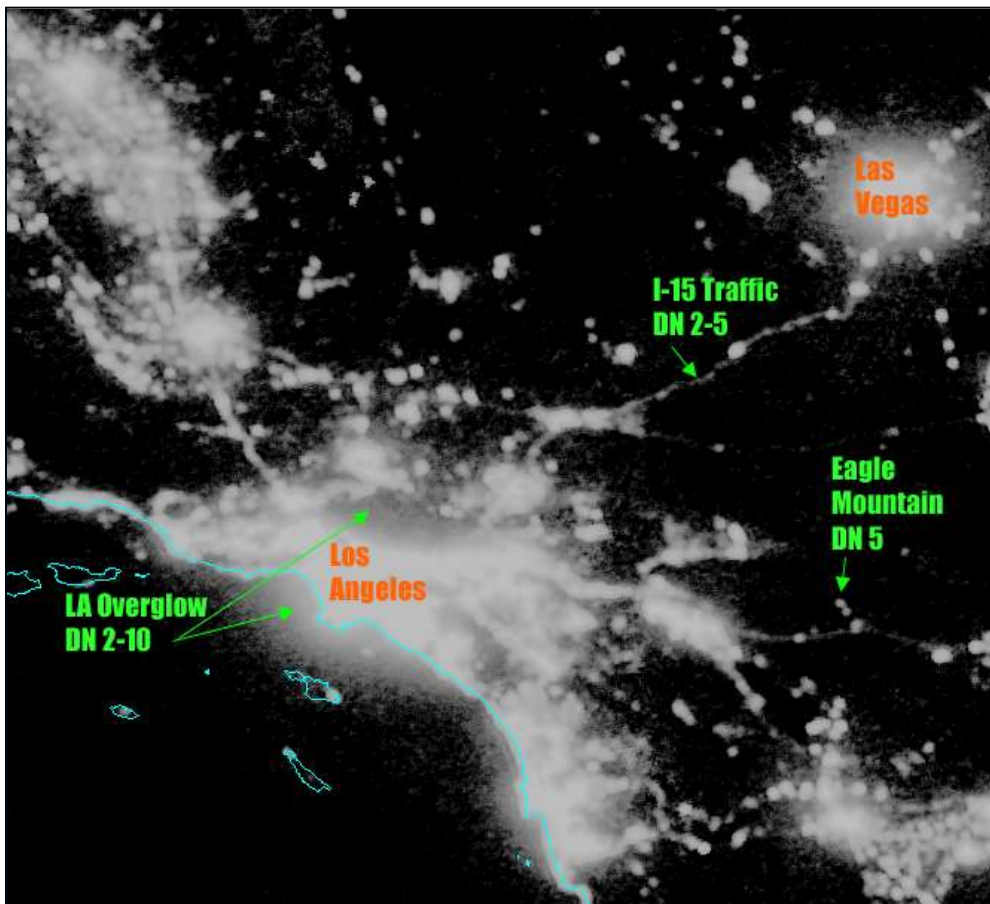


WDPA data issues

- General availability of PA data
 - UK, version 2009
- Availability of PA boundaries
 - Point feature buffering (Sample: Austria)
 - Cp. 6 National Parks

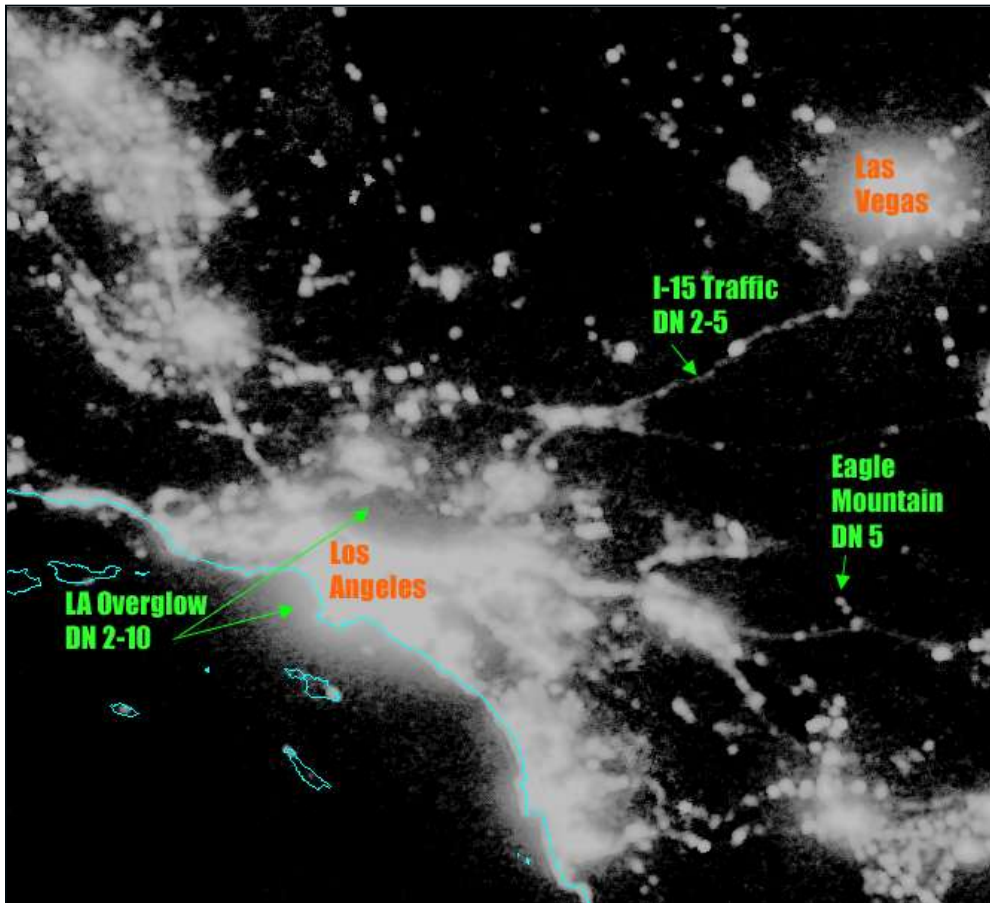


Shortcomings of DMSP lights



- Coarse spatial resolution
 - 2.5 km GSD
- OLS lights are larger than sources on the ground → ‘**Overflow**’ surrounds bright sources
- No visible band calibration
- 6 bit quantification

Shortcomings of DMSP lights



- Urban centers **saturate** in operational data
- No spectral information on the **type of the lighting** or changes in lighting type

Outlook

■ Future possibilities

- The **NPOESS** Visible Infrared Imaging Radiometer Suite (**VIIRS**) was to provide improved nighttime lights over the OLS
 - Issues with sensor development – delays...
 - NPOESS Preparatory Project was postponed until 2011 (initially 2005)
 - NPOESS satellite partnership dissolved - two separate lines of polar-orbiting satellites to serve military and civilian users: (1) JPSS Joint Polar Satellite System, (2) DWSS Defense Weather Satellite System
- **Metop** is considering adding a low light imaging sensor for flights planned a decade+ from now
- **Low light imager planned for GOES-R**, dropped due to financial constr.

Higher spatial resolution / multispectral nighttime lights?

- The **Nightsat** Mission concept

A high-angle, nighttime satellite photograph of Chicago, USA. The city's grid pattern is clearly visible, with numerous bright lights from buildings and streets. The surrounding areas are darker, with some greenery and less dense urban development. The image is taken from the International Space Station, showing the city's layout from a perspective that is not possible from the ground.

Digital camera image
from the
International Space Station
acquired by
astronaut D. Pettit

Chicago, USA



Tokyo, Japan



Jeddah, Saudi Arabia



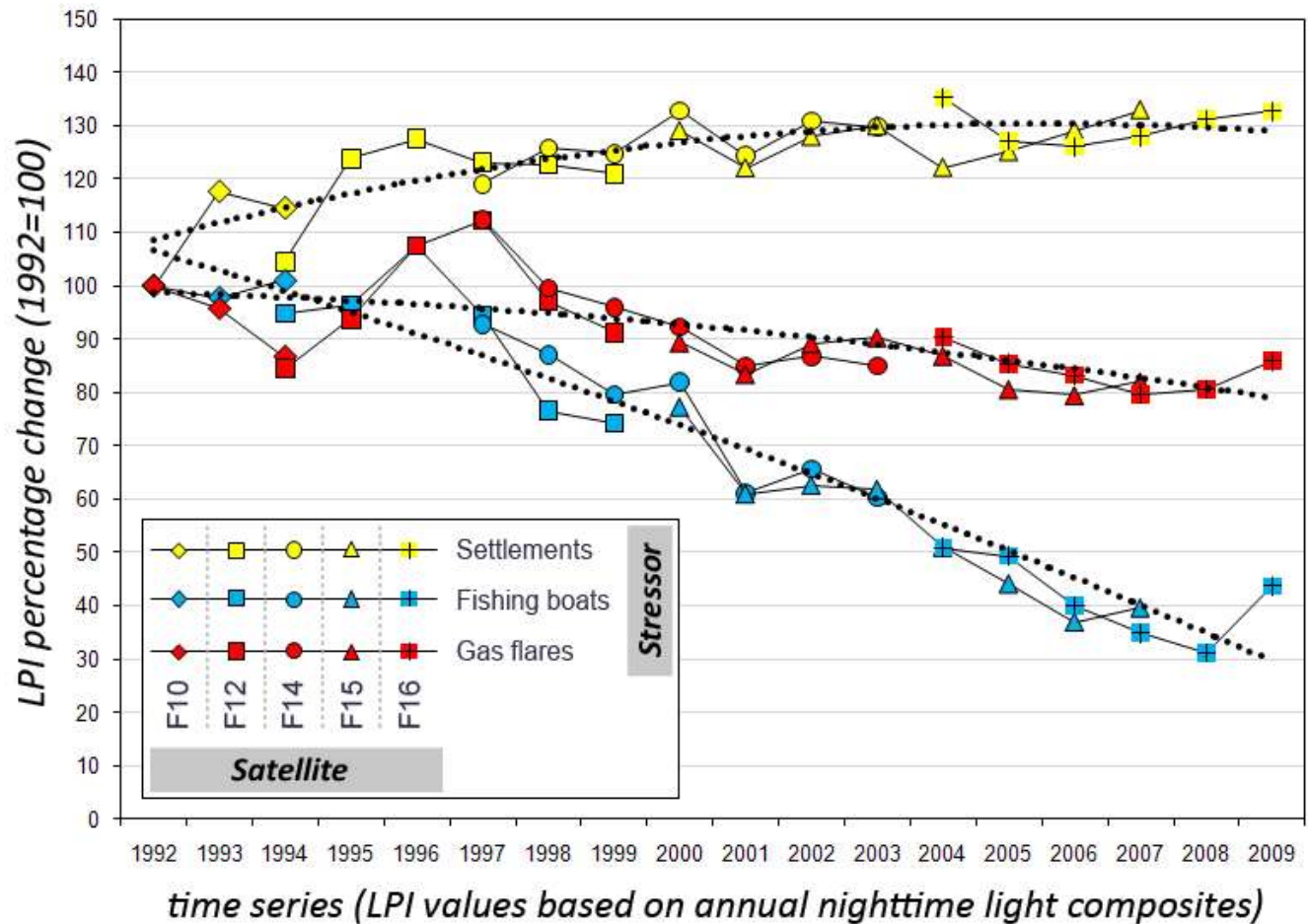
Washington D.C., USA

Urgent need for **Urban Lighting Governance** framework

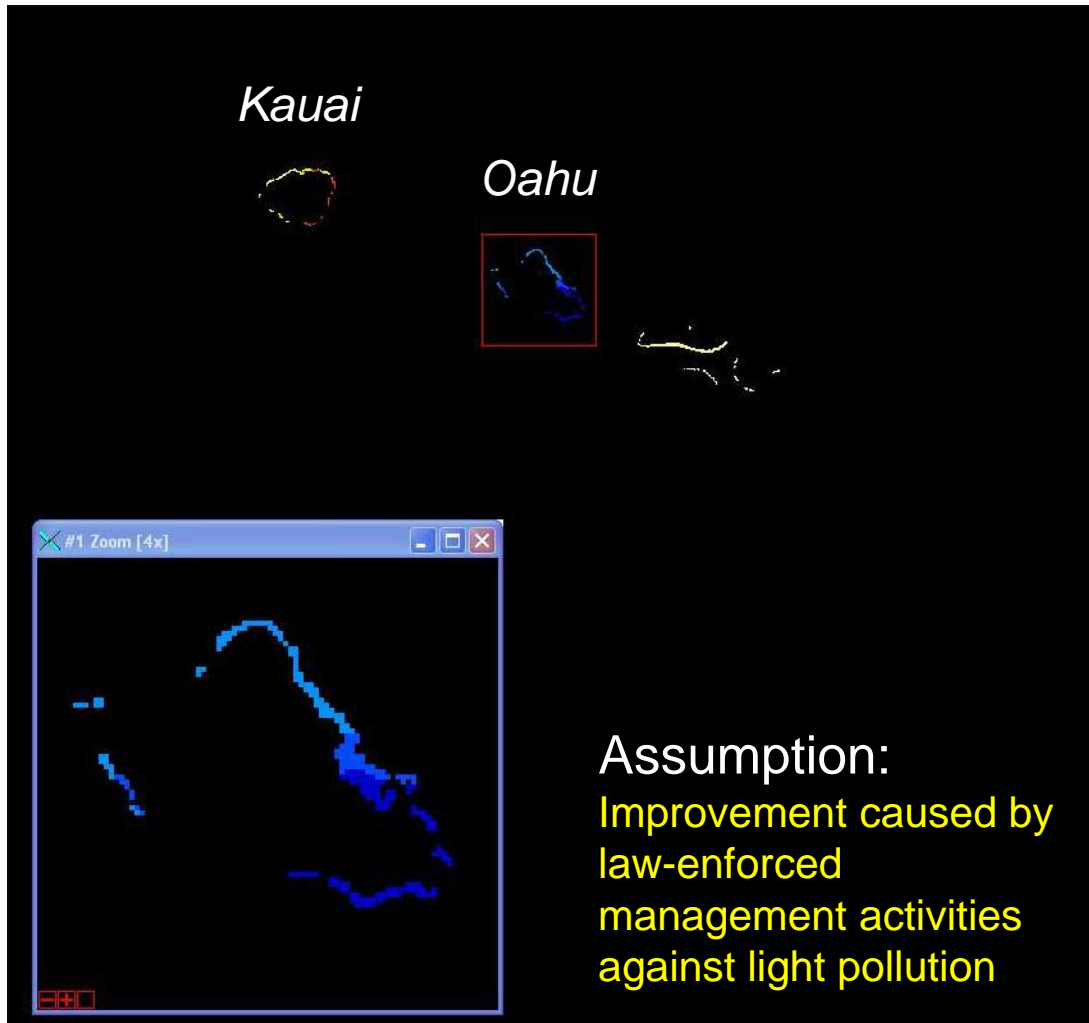
- **Control and management** of artificial night lighting...
... particularly in close proximity to **protected areas**
- Raise awareness of the issue of **light pollution** and related ecological consequences
 - Science
 - Public
 - Politics
- Legal implementation is important...
 - Lighting Law adopted (August 2007), **Republic of Slovenia**
 - Rules for lighting proposed and fights for legislative measures, e.g. **Czech Republic, Switzerland, Germany**

... and effects can be monitored!

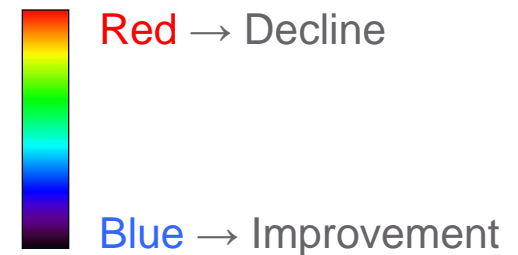
Coral reef related research – Exposure assessment



Coral reef related research – Exposure assessment



Visualization of
temporal trends
(1992-2003) in
potential stress to
coral reefs



Cities LPI_temp
Hawaii



Thank you for your attention!

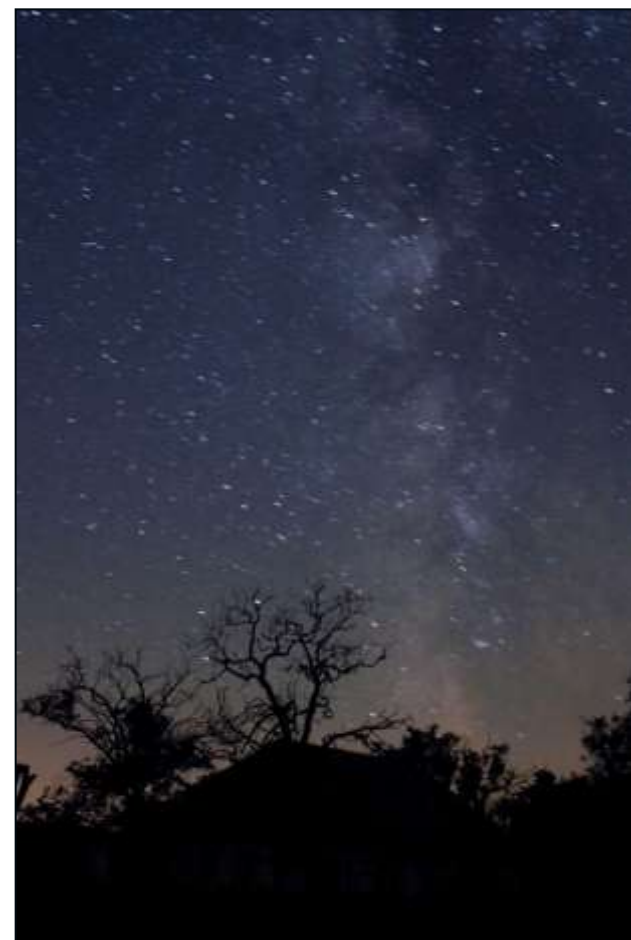
Christoph Aubrecht



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Hortobágy National Park, Hungary

Theme Issue Q4/2010

Ecosystems

Q1 – Earth Information Systems

Q2 – Observing the Oceans

Q3 – Global Human Health

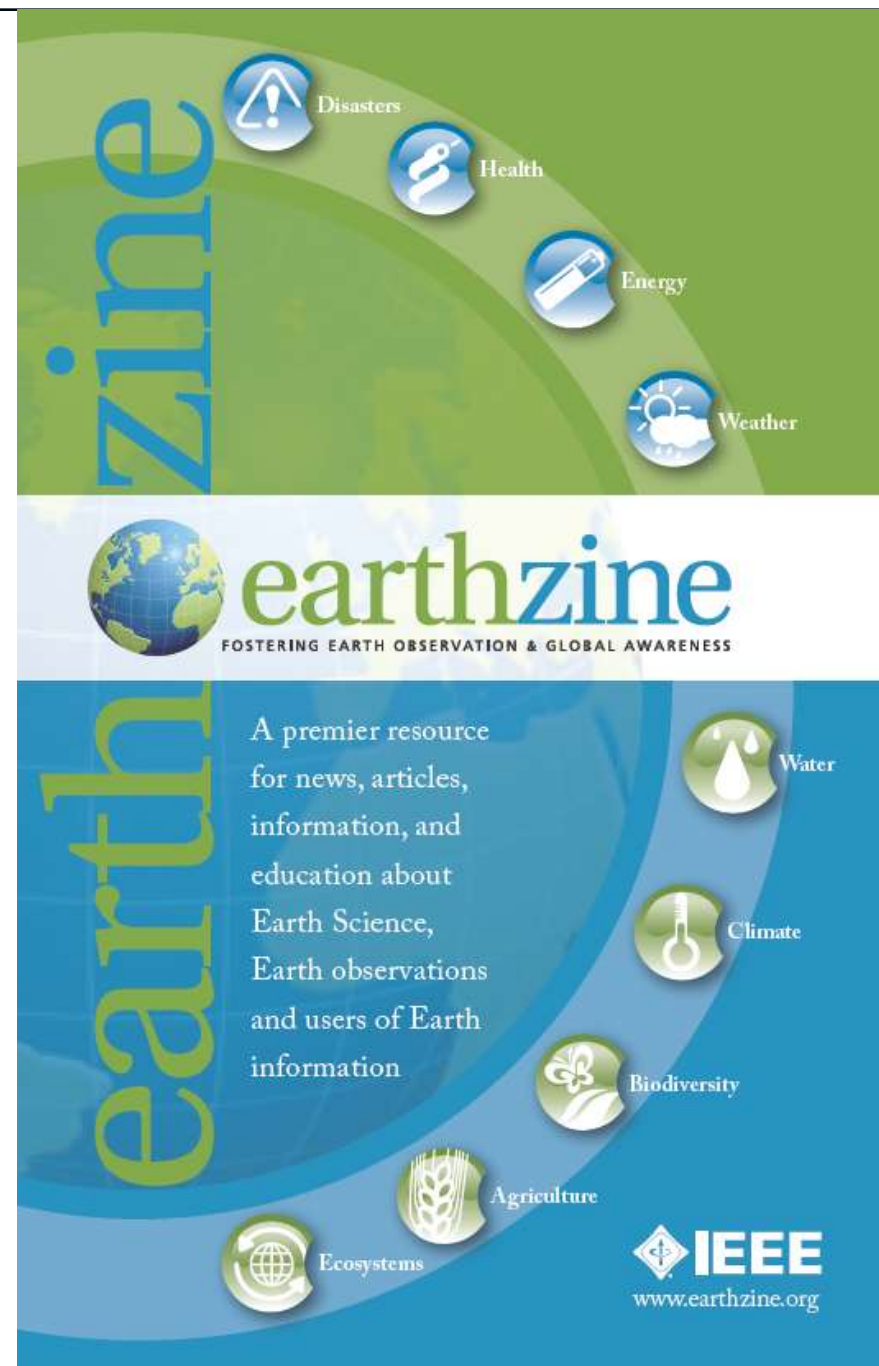
www.earthzine.org

IEEE Committee on Earth Observation
NASA National Aeronautics & Space Administration
EuroGEOSS
South Africa Dept. of Science & Technology

Christoph Aubrecht

Deputy Editor-in-Chief

christoph.aubrecht@earthzine.org



The image shows the Earthzine logo and cover design. The logo consists of a globe icon followed by the word "earthzine" in a blue, sans-serif font. Below the logo is the tagline "FOSTERING EARTH OBSERVATION & GLOBAL AWARENESS". The cover design features a green and blue background with a large, stylized "zine" in blue and "earth" in green. The cover is divided into two main sections: a top section with a green background and a bottom section with a blue background. The top section contains icons for Disasters (warning sign), Health (person with a pulse line), Energy (lightbulb), and Weather (sun and cloud). The bottom section contains icons for Water (water drop), Climate (flask), Biodiversity (flower), Agriculture (wheat stalk), and Ecosystems (globe). The text "A premier resource for news, articles, information, and education about Earth Science, Earth observations and users of Earth information" is centered in the blue section. The IEEE logo and the website URL "www.earthzine.org" are located in the bottom right corner.

zine

Disasters

Health

Energy

Weather

earthzine

FOSTERING EARTH OBSERVATION & GLOBAL AWARENESS

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