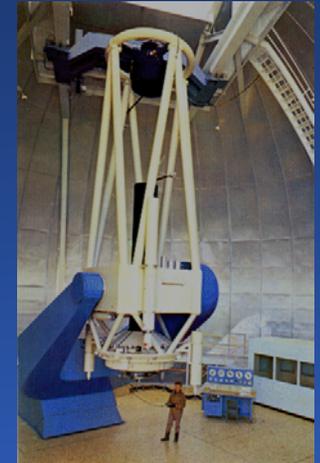
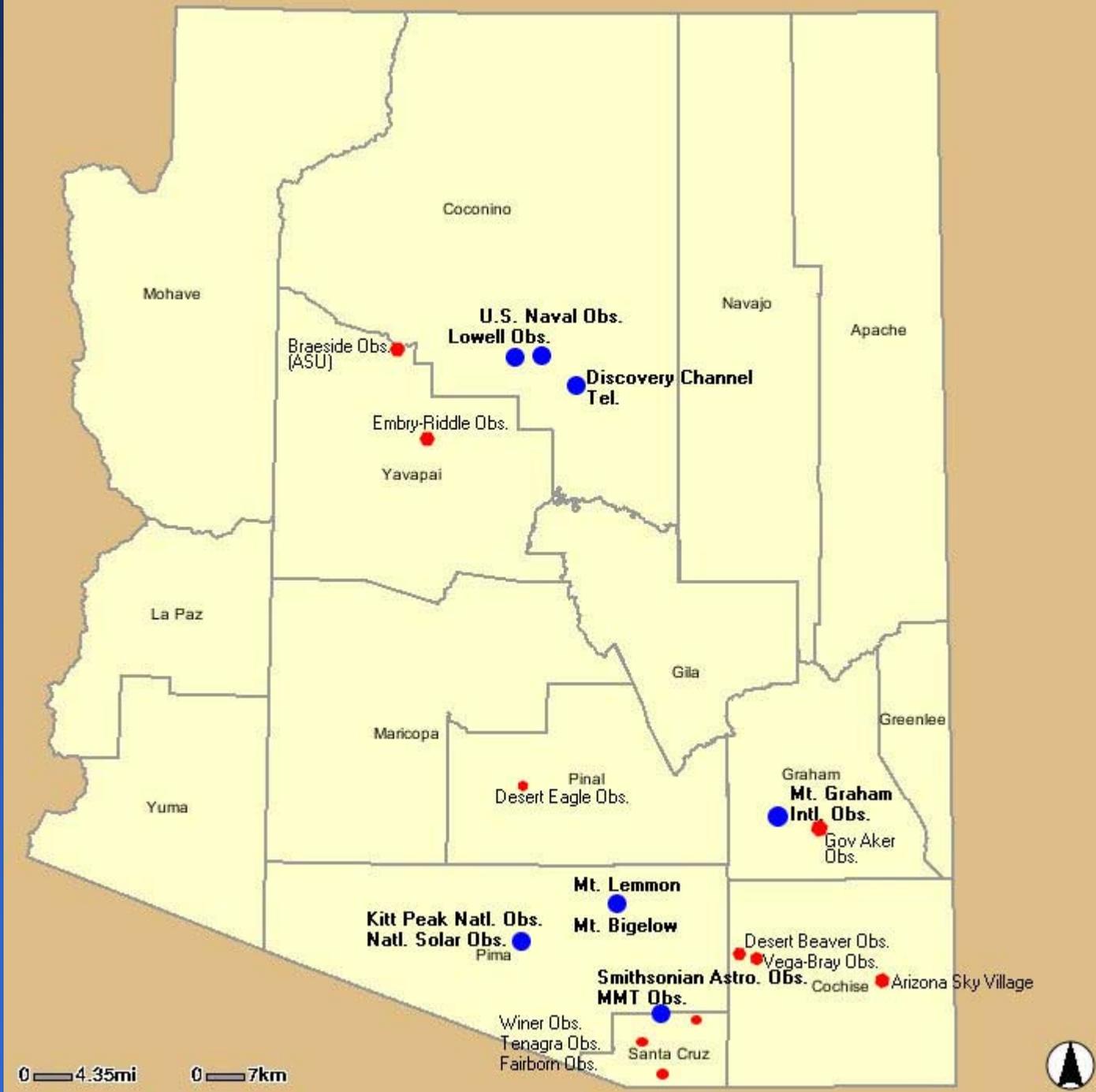


MAG Dark Skies Stakeholders Group
Tuesday, April 7, 2009.
Outdoor Lighting Lighting Codes



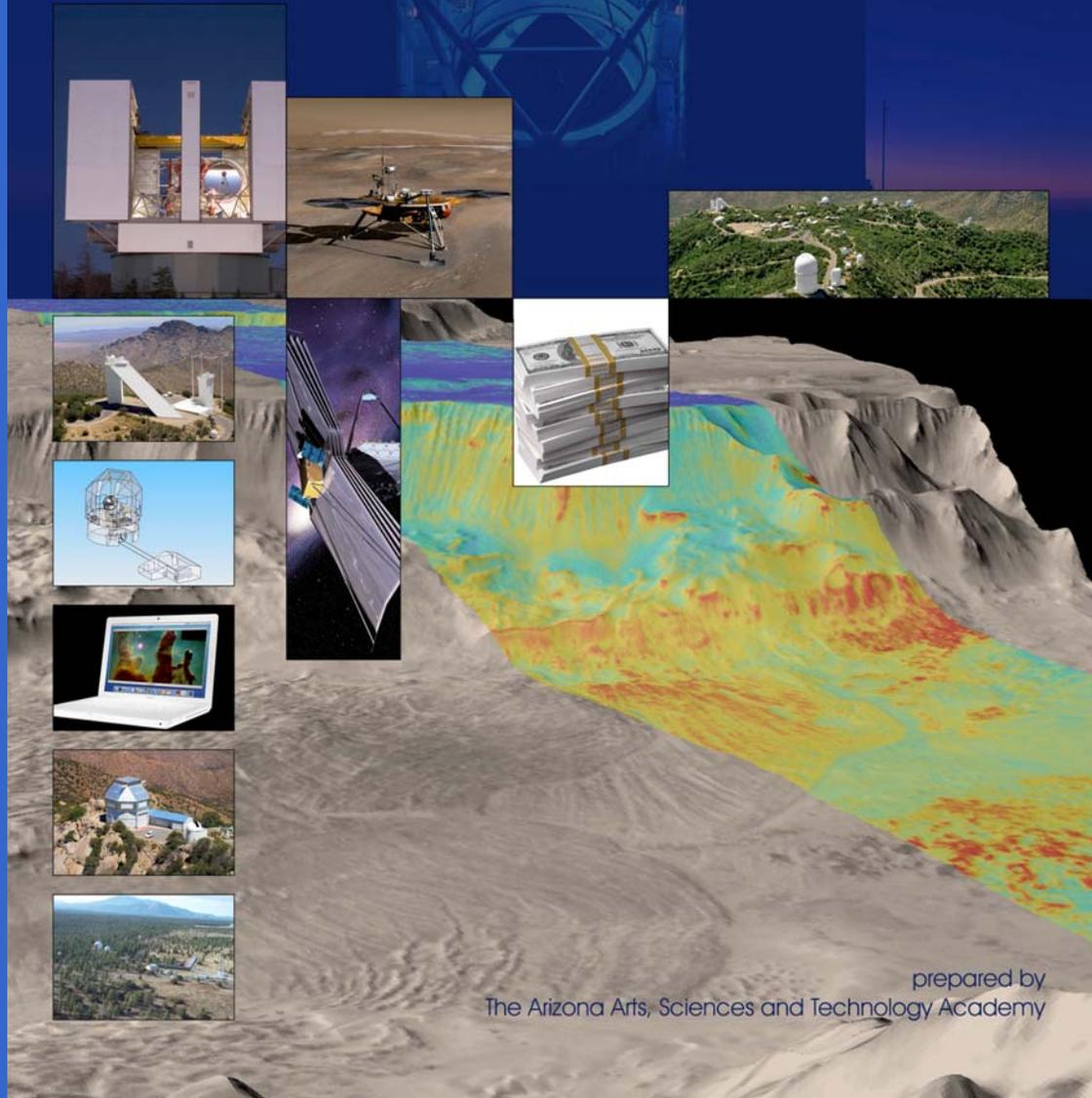
Dan Brocious, Smithsonian Institution, Whipple Observatory and
Chris Luginbuhl, U.S. Naval Observatory



Astronomy, Planetary Sciences, and Space Sciences Research Opportunities to Advance Arizona's Economic Growth

*Stargazing nets \$250 mil a
year for Ariz. economy*

*The Arizona Republic
January 17, 2008.*



Astronomy is worth billions to Arizona

This study found substantial capital investment

(in excess of \$1 billion) in,

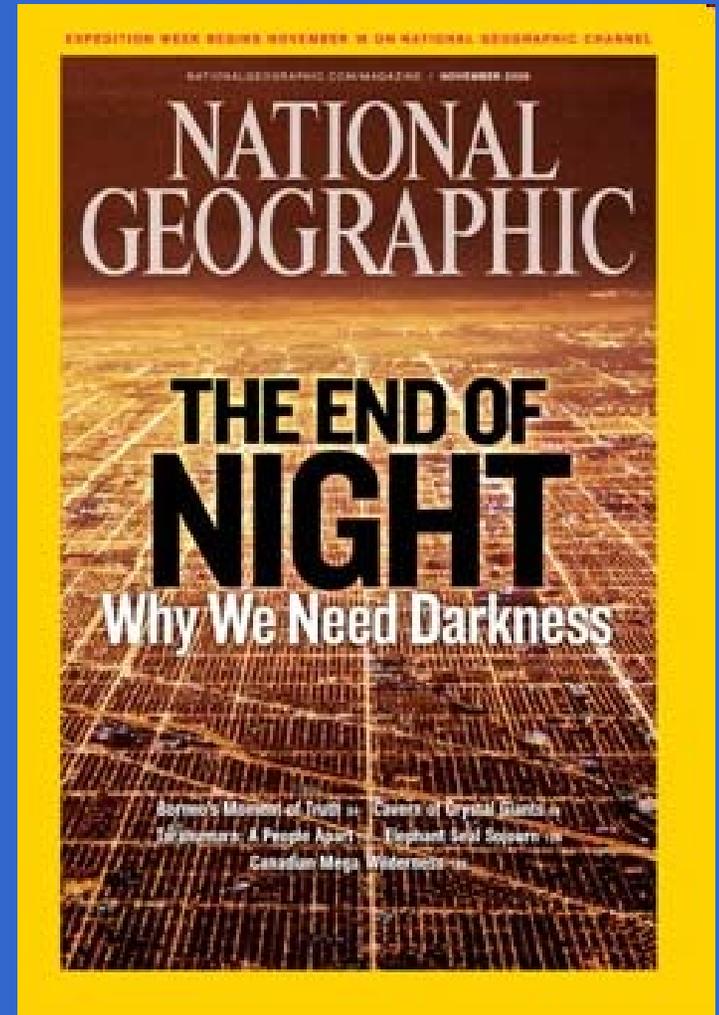
and economic return

(more than quarter of a billion dollars annually)

from APSS research in Arizona. The data also suggest the untapped potential of these research fields to expand the State's economic base. The study revealed levels of active research funding that well exceed other fields in the State, such as bioscience funding from the National Institutes of Health.

Light Pollution

Any adverse effect of artificial light including sky glow, glare, light trespass, light clutter, decreased visibility at night, and energy waste.



The Earth at Night



North America at Night



Eastern United States



Midwestern United States



A view of the upper Midwest. Note the development of small towns and other lighting sources along the highway systems.



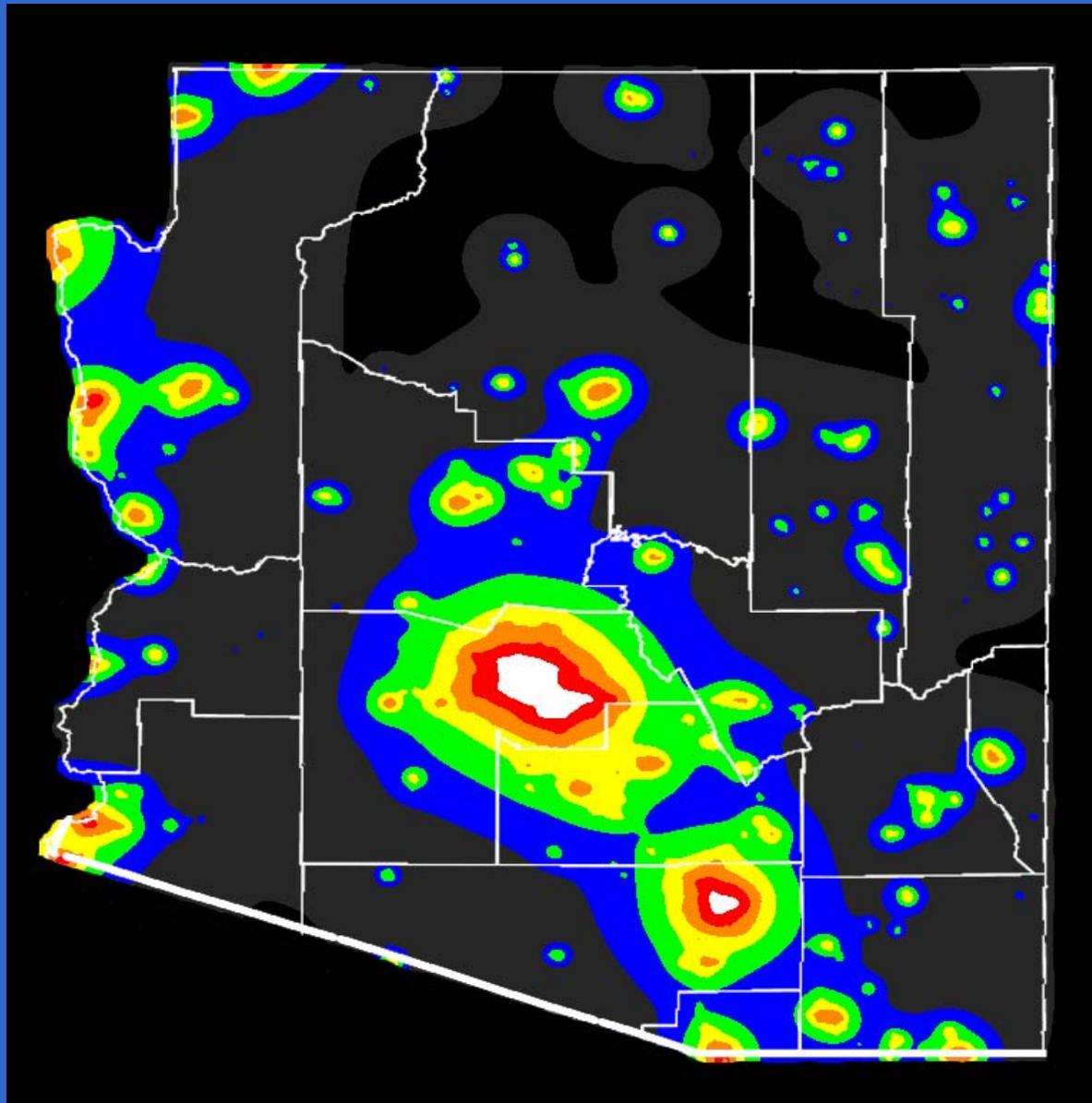
Southwestern United States, home of many of the large telescopes in the continental United States.



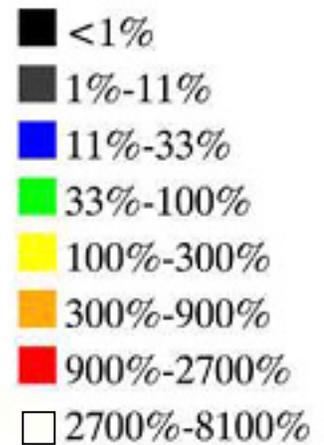
Lights as seen from above, as from the International Space Station, for example, looking down. Here the landscape outside of the cities looks dark. But this is misleading... it is not dark here.

The next slide shows what these lights do to the sky, in other words, what it looks like looking upwards, the other direction, showing that light pollution spreads much farther than the cities in which the lights are used... you can be 50 or 100 miles from the Phoenix metropolitan area and still see the effects of the city lights

Light Pollution in Arizona

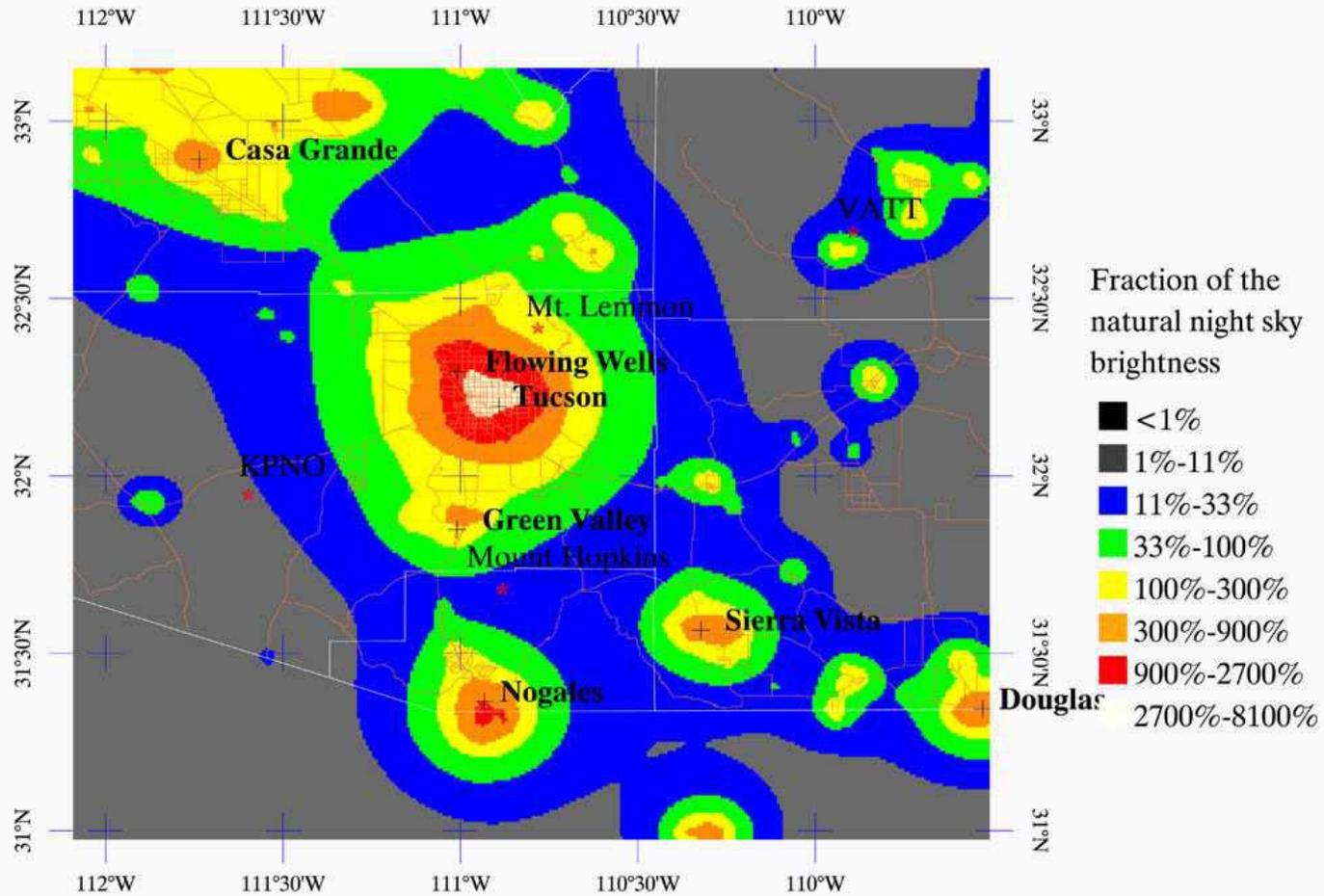


Fraction of the
natural night sky
brightness



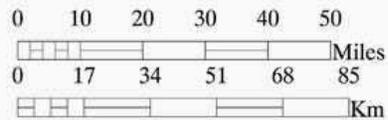
(Cinzano, Falchi, Elvidge)

Artificial night sky brightness near Tucson



Cinzano/Falchi/Elvidge 2002 ISTIL/NGDC

Zenith night sky brightness at sea level
clear standard atmosphere
OLS-DMSP 1996/1997 data



Map Scale 1:1,600,000

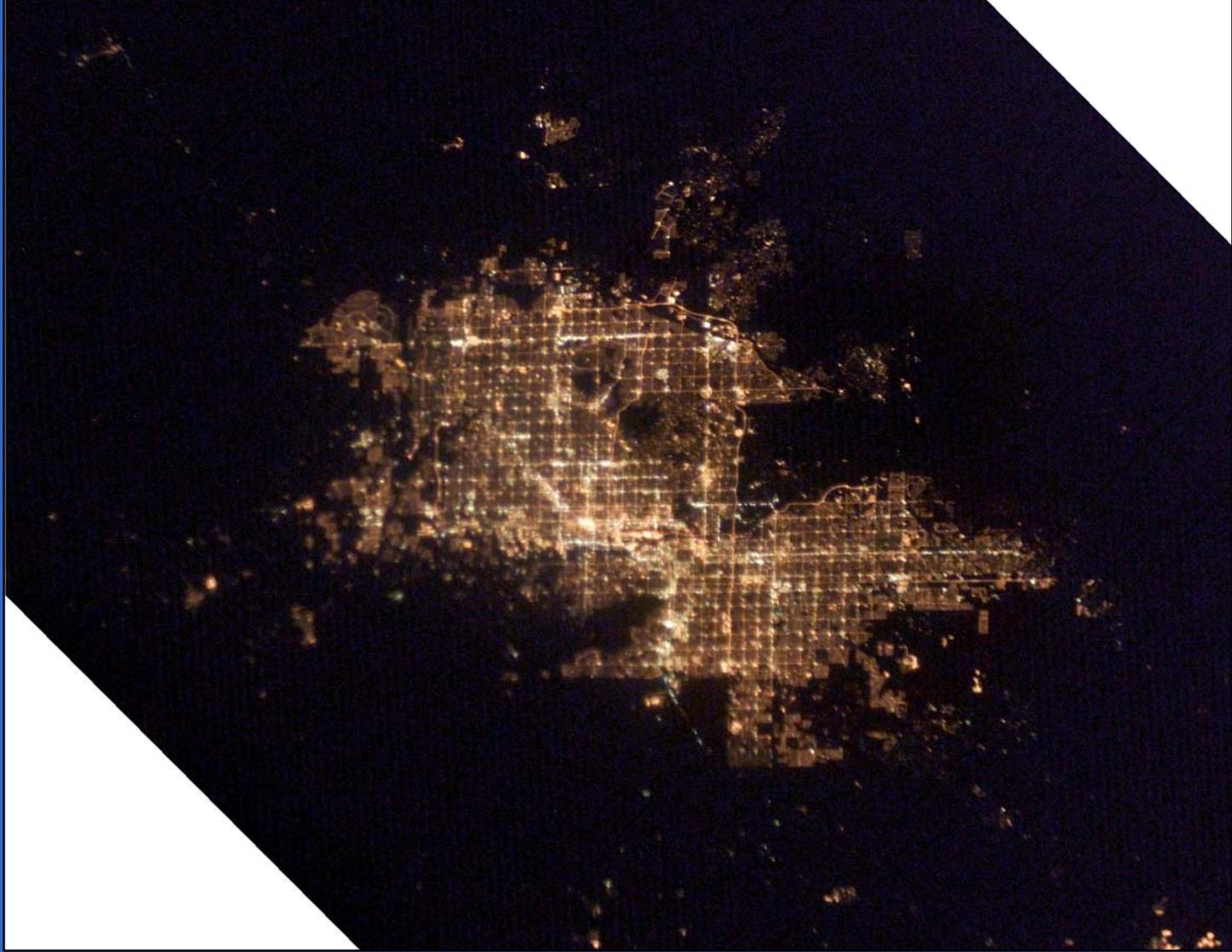
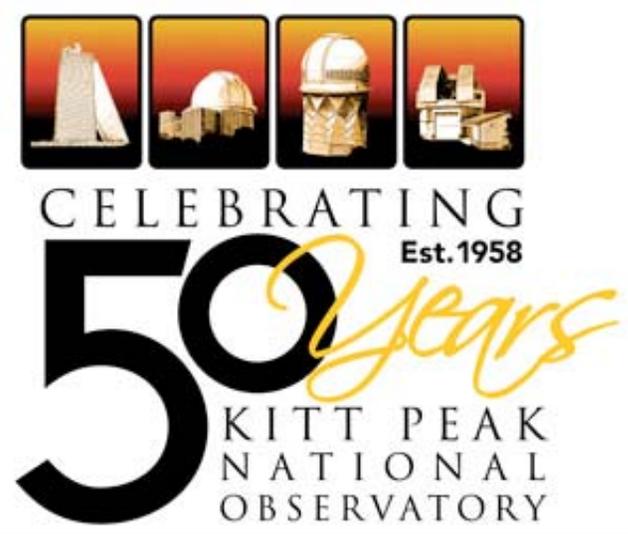


Image of Phoenix at night taken from the International Space Station
(~220 miles above) (NASA, ISS CEO project)



Phoenix/Casa Grande sky glow as seen from Kitt Peak National Obs.

March 28, 2008. (KPNO photo by J. Glaspey)



50th Anniversary of the National Observatory





Tucson sky glow
as seen from Whipple Obs.

Los Angeles in 1908,
as seen from Mt. Wilson Observatory.



Los Angeles basin from Mt. Wilson Observatory, 1 hour exposure by Ferdinand Ellerman, 1908.

Kitt Peak National Observatory, Photo File No. 11781

Los Angeles in 1988, as seen from Mt. Wilson.





M 101

Purpose of a Lighting Code:

- Promote good lighting practice,
 - And to limit obtrusive lighting.
- Promote good business.
- Promote the community.
- Help everyone see better.
- Save energy. Save money.
- Preserve dark skies for all.

Code elements to promote good outdoor lighting

Fixture type -- put the light on the ground where it is needed and useful.

Amount of light -- prevent over-lighting with lumens limits

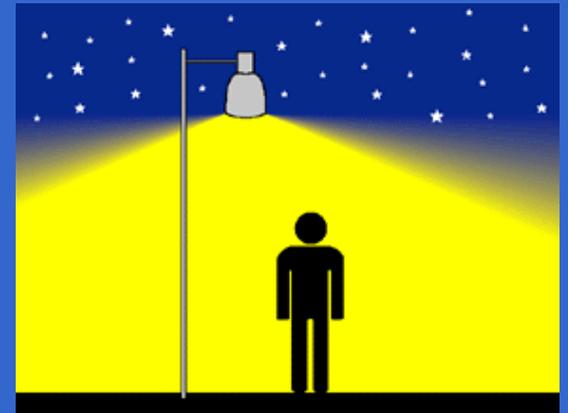
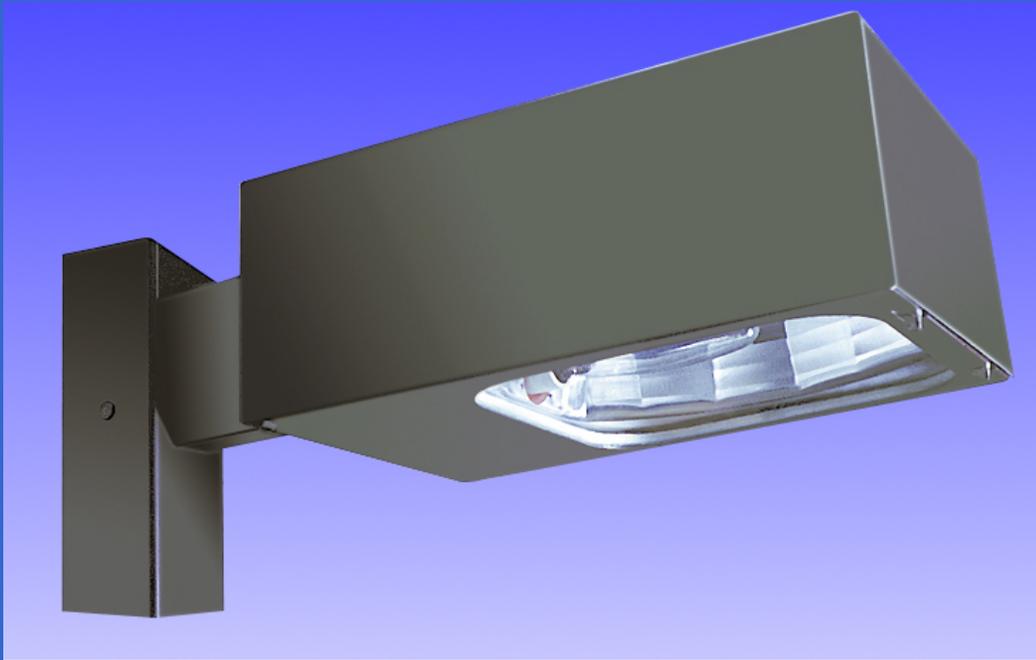
(but use what is necessary for the task).

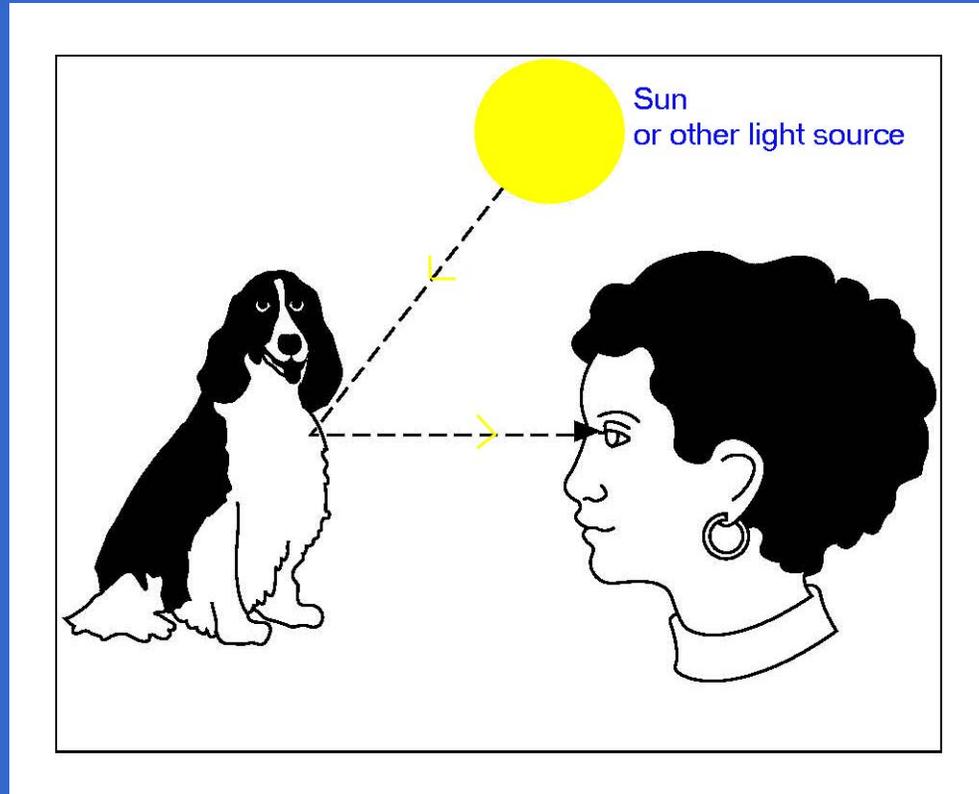
A lighting budget also saves energy and money

Time of light use -- turn it off when not needed (curfew)

Color of light -- to protect most sensitive dark sky areas.

Full Cut-Off (FCO)



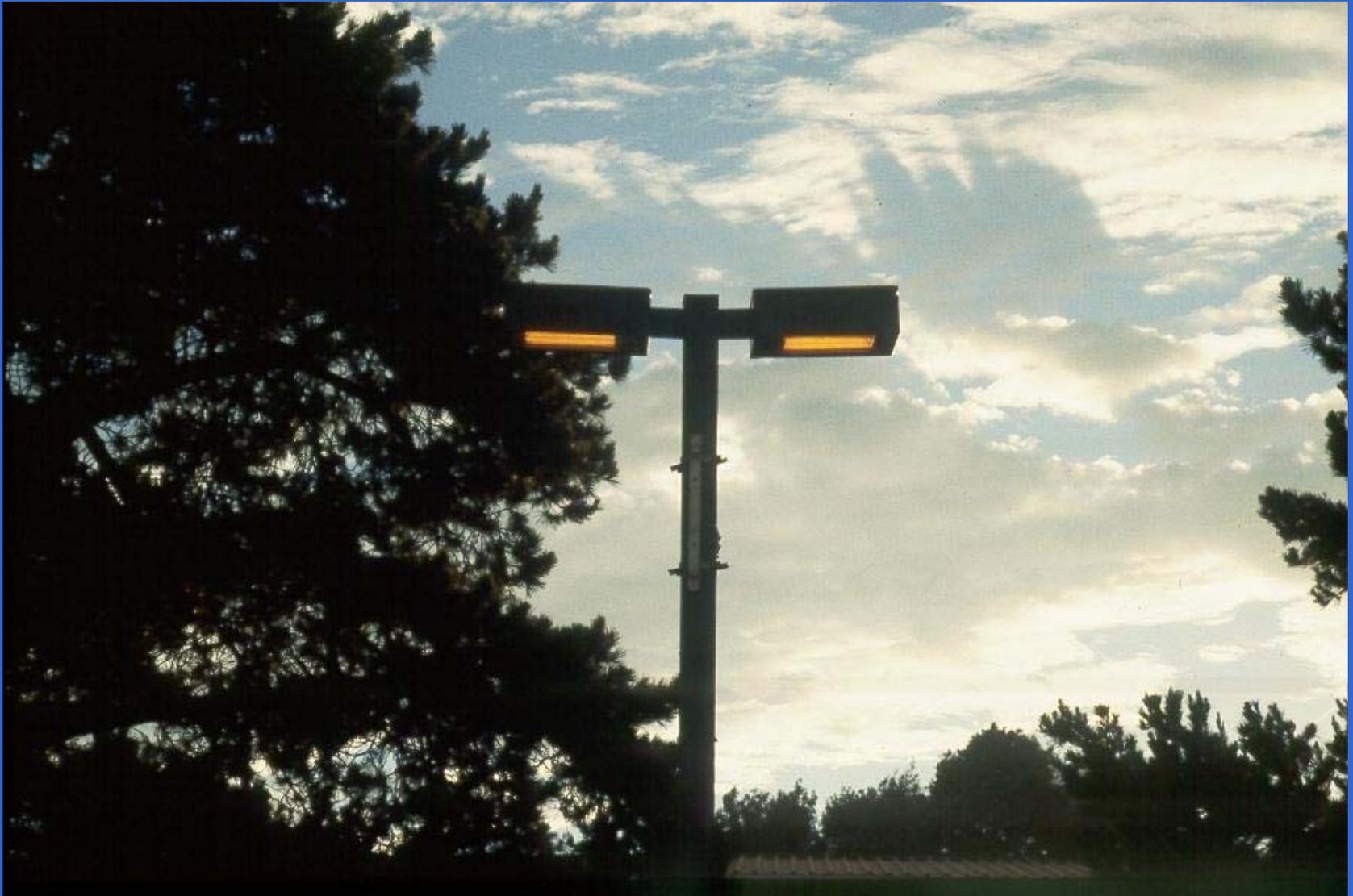


We see an object when light reflects from it into our eyes.

Glare bomb lighting a tree,
not doing a good job for the parking lot.



A full cutoff “shoe box” street or area lighting fixture, with an HPS lamp.



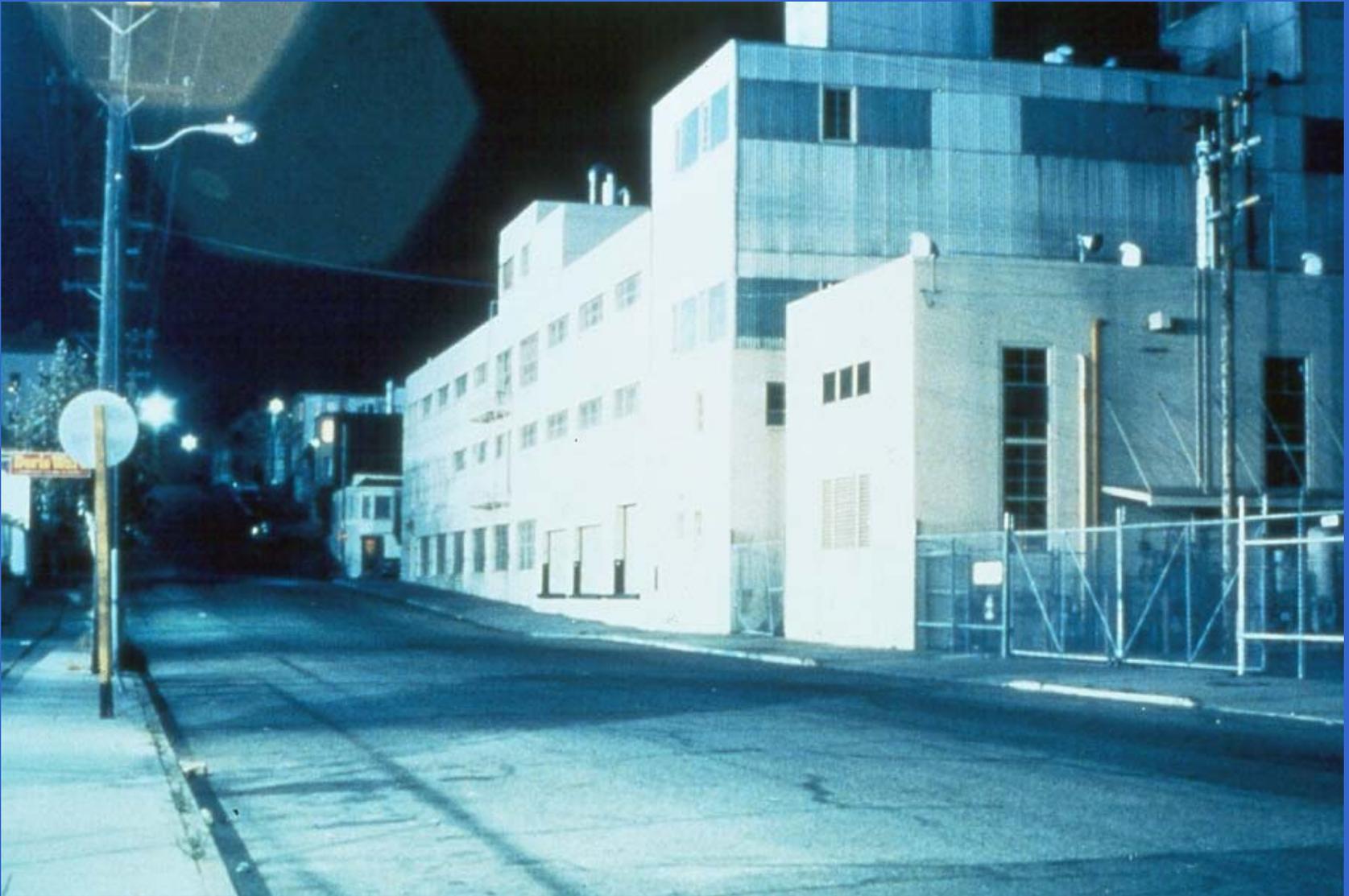
A Tucson street scene, illustrating the good street lighting.



How is this for a good lighting design?
Bureaucracy in action!



Almost a definition of light trespass,
at an installation in San Francisco.

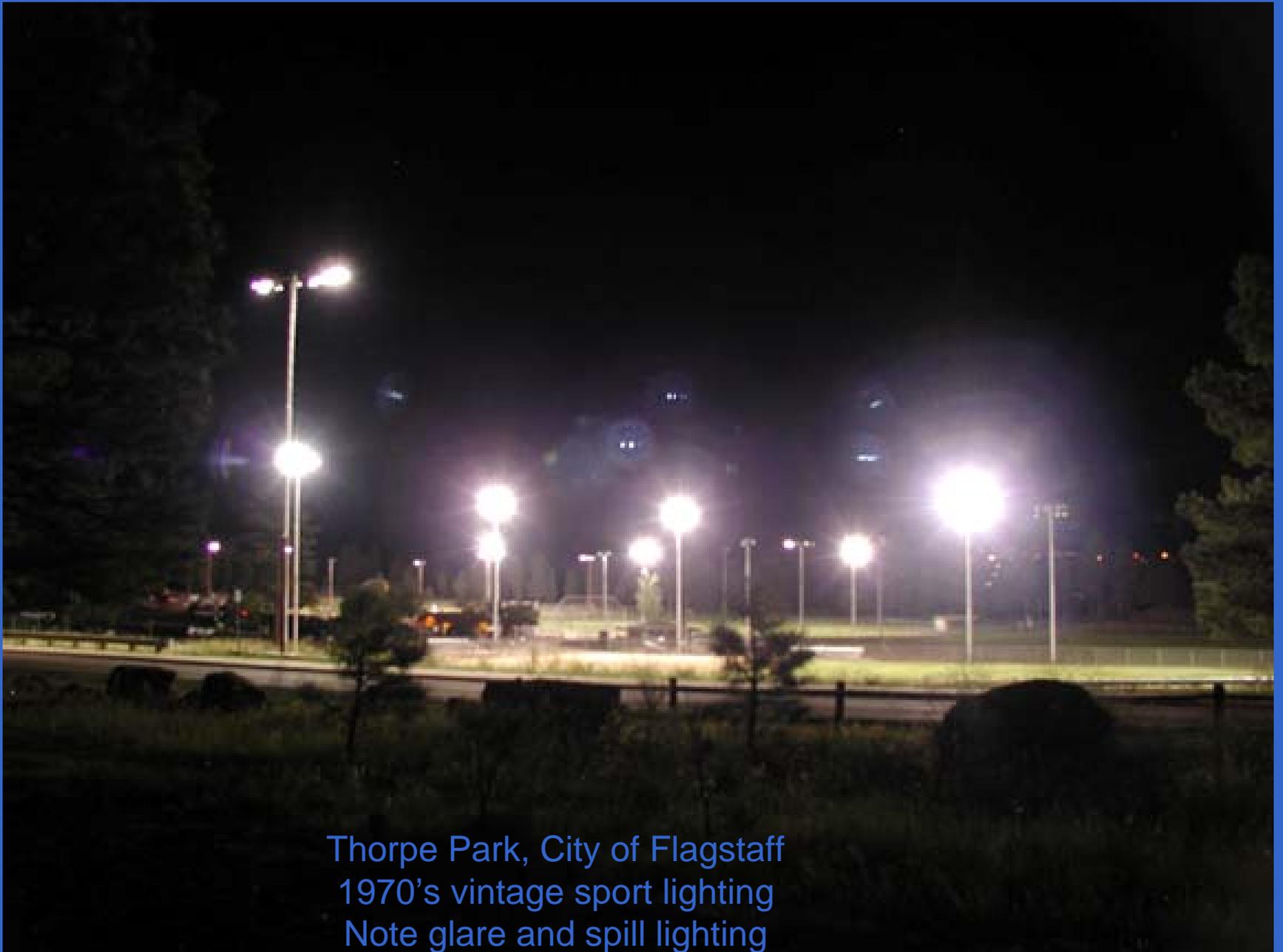


Here we see a student on the walkway.



She moved about four feet.





Thorpe Park, City of Flagstaff
1970's vintage sport lighting
Note glare and spill lighting

A nighttime photograph of a baseball field at Thorpe Park, City of Flagstaff. The field is brightly lit by several tall, modern stadium light towers. The infield is a mix of brown dirt and green grass, while the outfield is a uniform green. In the background, a large, modern stadium building with a glass facade is visible, illuminated from within. The sky is dark, and the overall scene is a well-lit sports venue at night.

Thorpe Park, City of Flagstaff
Modern sport lighting circa 2006

Benefits:

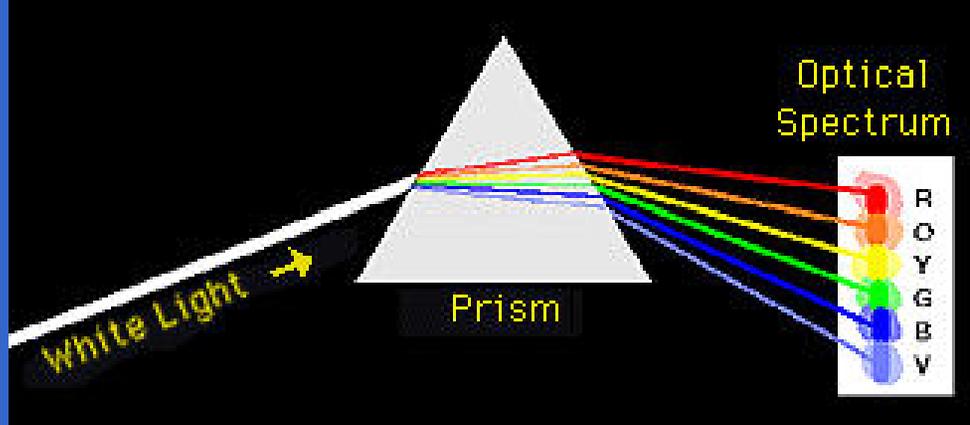
Light levels on playing field are twice previous.

Players and spectators can see better.

No light trespass into surrounding neighborhood.

Better energy efficiency.

Everyone wins.



White light passing through a prism.



Photo courtesy NASA
Continuous spectrum of white light.



Photo courtesy NASA
Hydrogen spectrum

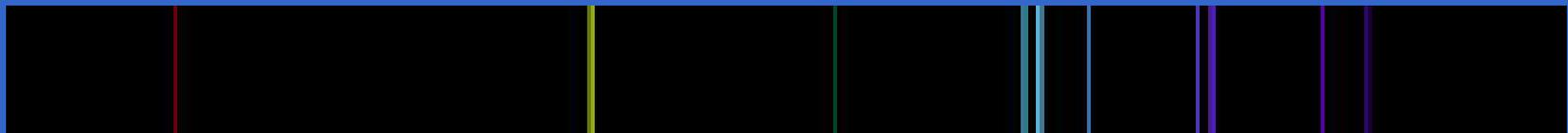
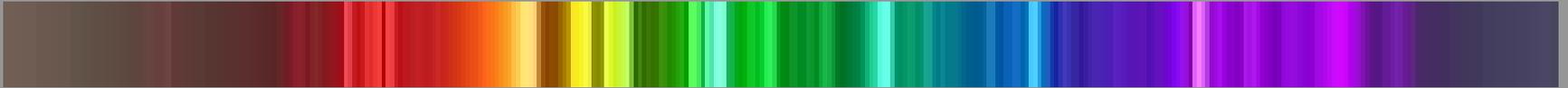


Photo courtesy NASA
Helium spectrum



Typical metal halide lamp spectrum



Typical fluorescent lamp spectrum



Typical high pressure sodium lamp spectrum



Typical low pressure sodium lamp spectrum

A photo of a street in Redwood City, CA,
with a transmission grating in front of the lens.



City of Flagstaff Signs & Lighting Regulations

Chapter 10-08: Signs and Lighting

Page 1

CHAPTER 10-08. SIGNS AND LIGHTING

DIVISION 10-08-001 SIGN REGULATIONS.

10-08-001-0001. PURPOSE AND INTENT:

The City Council finds that the natural surroundings, climate, history, and people of the City of Flagstaff combine to provide the Flagstaff community with unique charm and beauty. This Division has been adopted to assure that signs installed in the City of Flagstaff are compatible with the unique character and environment of the community.

(Entire Division adopted by Ord. 1946, 6-17-97)

Common forms of sign lighting regulation

Internally illuminated signs

Sign size (larger signs emit more light)

Sign color (darker colors emit less light)

How long is sign lit? (curfew)

Externally illuminated signs

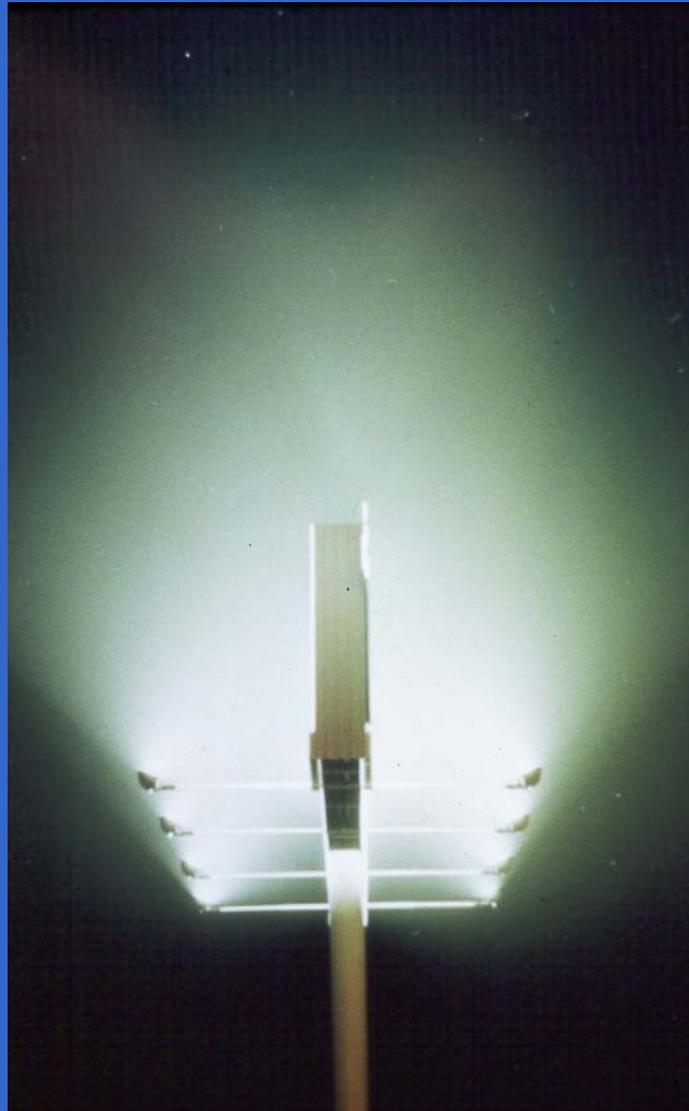
Type of light fixtures (full cut off)

How mounted (top mounted)

How much (lumens limit)

How long is sign lit? (curfew)

A billboard, seen from the side.



Externally illuminated sign

Cortaro & I-10



10 - Brown
100 - White Letters

240 - White

1 - Blue
125 - White Letters

100 - Yellow

0 - Blue
50 - White Letters

2 - Red
125 - White Letters

250 - White

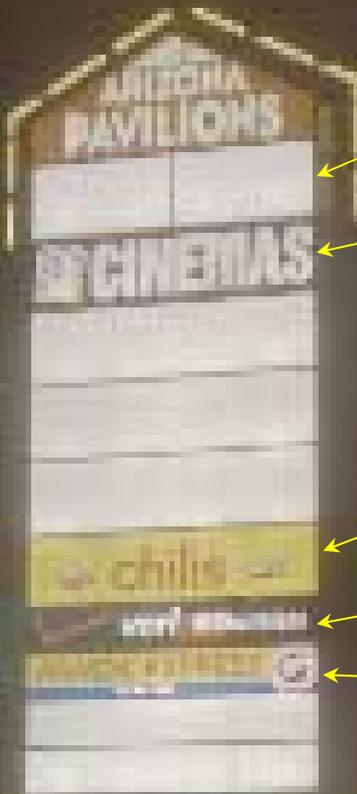
10 - Green
125 - White Letters

0 - 100

110 - White

Internally illuminated sign

Cortaro & I-10



250 - Whites without text

150 - White Letters

100 - Yellow background

200 - White Letters

100 - Yellow background

Internally illuminated sign



Cortaro & I-10

Signs illuminate
the parking lot

Parking lot
lights are OFF



Pima County Lumens Cap Table

Table 401.1
Maximum Total Outdoor Light Output Requirements
Lumen Caps: Mean Lumens per Net Acre (4)

	Lighting Area as Defined in Chapter 3					
	E3	E3a	E2	E1c	E1b(5)	E1a(5)
Commercial and industrial "Option 1" (1)(2) (mostly LPS lighting)						
Total (full cut-off LPS, plus full cut-off non-LPS)	450,000	350,000	200,000	125,000	48,000	18,000
Limit on non-LPS full cut-off.	45,000	35,000	18,000	6,000	3,000	3,000
Limit on unshielded component (LPS or non-LPS)	12,000	9,000	6,000	3,000	3,000	0
Commercial and industrial "Option 2" (1)(2) (full cut-off for all lighting)						
All lighting must be full cut-off	300,000	150,000	65,000	25,000	25,000	12,500
Limit on unshielded component	0	0	0	0	0	0
Commercial and industrial "Option 3" (1)(2) (full cut-off for most lighting)						
Total (full cut-off plus unshielded)	200,000	100,000	50,000	25,000	12,500	12,500
Limit on unshielded component	12,000	9,000	6,000	3,000	3,000	0
All residential zoning (3)(4)						
Total (full cut-off plus unshielded)	55,000	39,000	24,000	15,000	12,000	12,000
Limit on unshielded component	12,000	9,000	6,000	3,000	3,000	3,000

PHILIPS



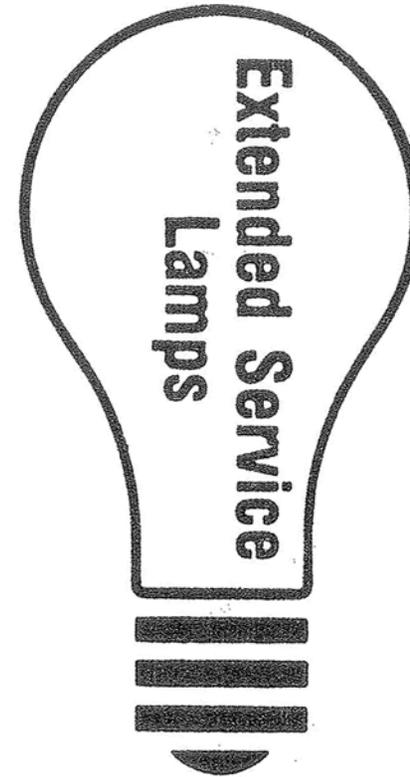
Comparative Data

Extended Service:			Standard:	
Watts	Avg Hours	Avg Lumens	Avg Hours	Avg Lumens
40	2500	415	1500	480
60	2500	740	1000	890
75	2500	1000	750	1220
100	2500	1480	750	1710

Philips Lighting Company
P.O. Box 6800 • Somerset, NJ 08875-6800
A Division of North American Philips Corporation

Made in U.S.A.

HX-A192C-S
810838



2 Lamps



SEDONA OUTDOOR LIGHTING APPLICATION

City of Sedona • 102 Roadrunner Drive • Sedona, AZ 86336
928-282-1154

Permit # B: _____

Date Received: _____

Approved: Not Approved:

Staff Initial: _____

1. Applicant Information:

Name _____

Mailing Address _____

Phone No. _____

2. Site Identification:

Business Name (if applicable) _____

Location _____

Assessor's Parcel Number _____ - _____ - _____

3. Lumen Information (non-residential and multi-family uses):

Gross acres of entire site _____

Acres for Public Right-of-Way - (_____)

Net Acreage of Site _____ X 100,000* = _____
(Total Lumens Permitted)

4. Type of Shielding and Lumens Proposed: (see Lumen Calculation Table)

Fully Shielded Fixtures:	Lumens Proposed: _____
Partially Shielded Fixtures:	Lumens Proposed: _____
	TOTAL LUMENS PROPOSED: _____ <i>(fully and partially shielded fixtures)</i>

* Total outdoor light output shall not exceed 100,000 lumens per net acre for all development except single-family residential uses. This cap is not intended to be achieved in all cases or as a design goal. Instead, design goals should be the lowest levels of lumens necessary to meet the lighting requirements of the site. Partially shielded light fixtures are limited to a

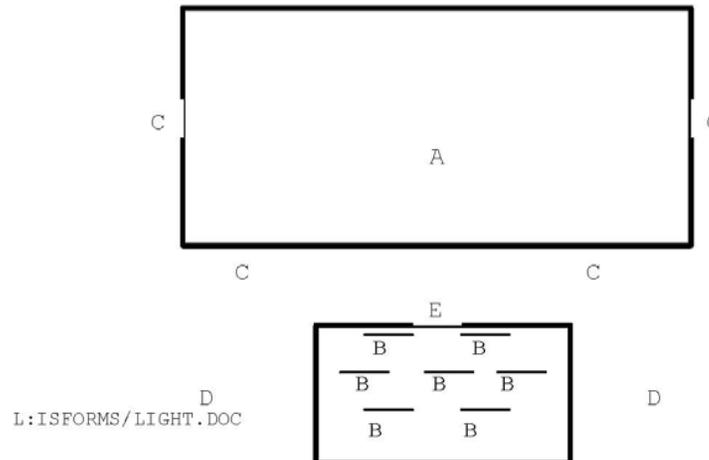
SAMPLE

Lumen Calculation Table

Lamp Type Key:	LPS Low Pressure Sodium	Shielding Key: F Fully Shielded
	HPS High Pressure Sodium	P Partially Shielded
	MH Metal Halide	U Unshielded
	FL Fluorescent	
	IN Incandescent (including quartz-halogen)	

Plan Key (ID)	Light Class (1, 2 or 3)	Lamp Type (LPS, HPS, MH, FL, IN)	Initial Lumens	No. of Units	Shielding (F, P or U)	Watts (each)	New or Existing (N or E)	Total Lumens
A	Interior	NA	NA	NA	NA	NA	NA	NA
B	1	FL	2,975	7	F	35	N	20,825
C	1	IN	1,750	6	F	100	N	10,500
D	2	LPS	13,500	2	F	135	N	27,000
E	1	MH	16,000	2	F	250	N	32,000
TOTAL LUMENS:								90,325

Plan Key identification in first column must correspond to labeling on site plan map.





- On the night of August 20, 2003, a blackout plunged millions of people across northeast North America into darkness. These photos dramatically tell the light pollution story. The left photo shows the glow filling the skies over photographer Todd Carlson's house in Goodwood, Ontario, Canada, (near Toronto). The right image shows the sky on the night of the blackout. The blackout image is a 90-second unguided exposure at $f/2.8$ on ISO 800 speed film through a 28mm lens. The sky glow picture was taken following night when power was restored, and is a 30-second exposure with the same setup. Photos copyright © 2003, Todd Carlson, used with permission.

THE UNIVERSE
YOURS TO DISCOVER



INTERNATIONAL YEAR OF
ASTRONOMY
2009

Astronomy2009.org

or

Astronomy2009.us

in the USA

IYA '09 will be a global celebration of astronomy and its contributions to society and culture.

Dark skies awareness is one of 11 IYA cornerstone projects.

www.darks skies awareness.org

www.astronomy2009.us/darks skies



