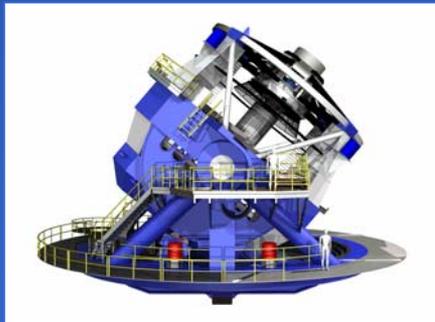
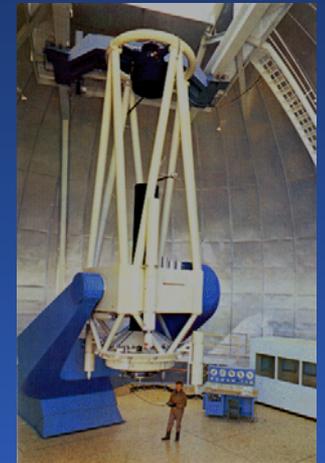


MAG Dark Skies Stakeholders Group  
Tuesday, February 15, 2011.  
***Outdoor Lighting Codes***



Dan Brocius, Smithsonian Institution, Whipple Observatory and  
Richard Green, Director, Large Binocular Telescope Observatory

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

*The Arizona Republic*  
January 17, 2008.

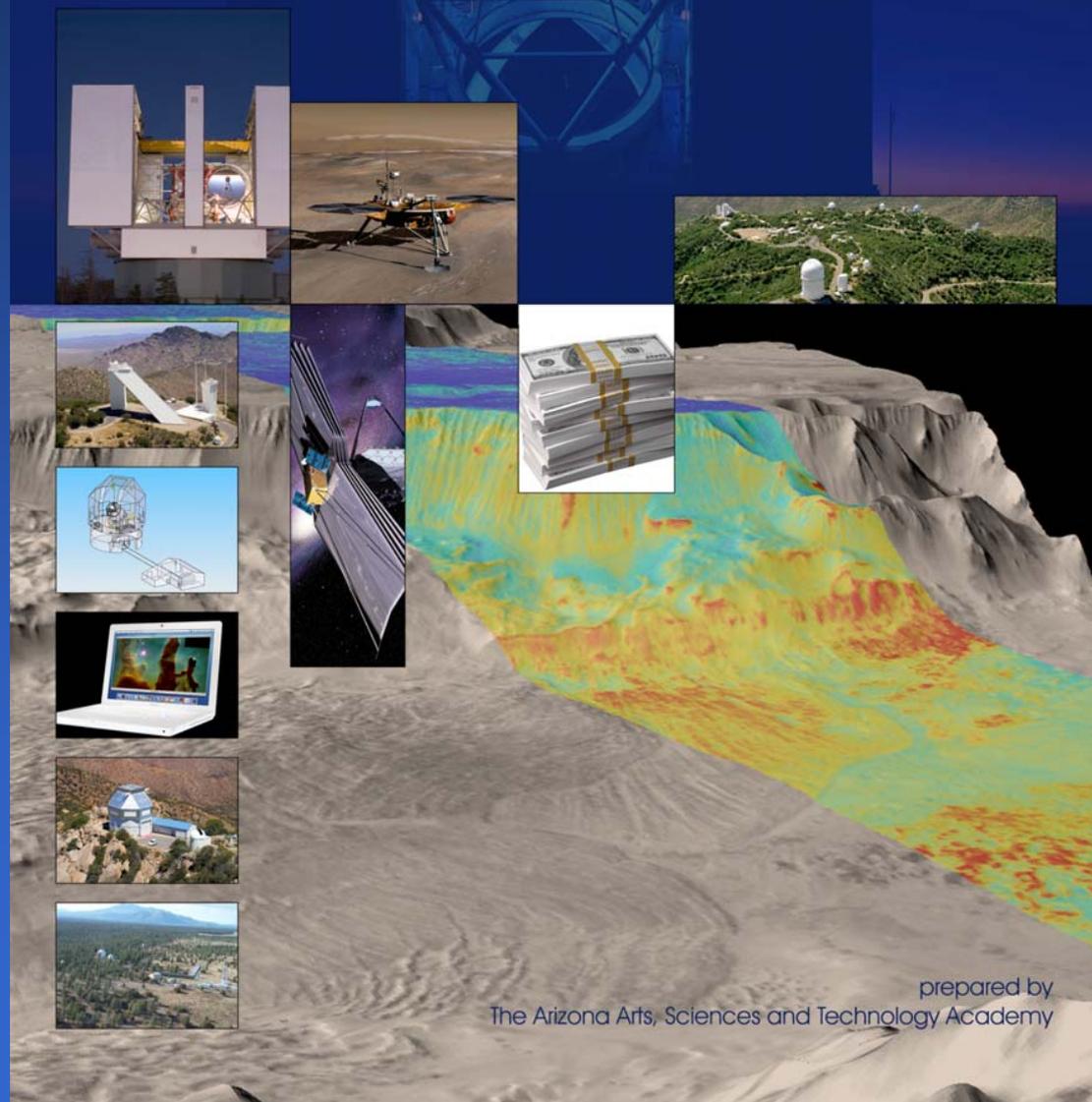
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AASTA study found **substantial capital investment (more than \$1 billion)** in, and **economic return (more than \$250 million annually)** from APSS research in Arizona. The data also suggest the untapped potential of these research fields to expand the State's economic base.

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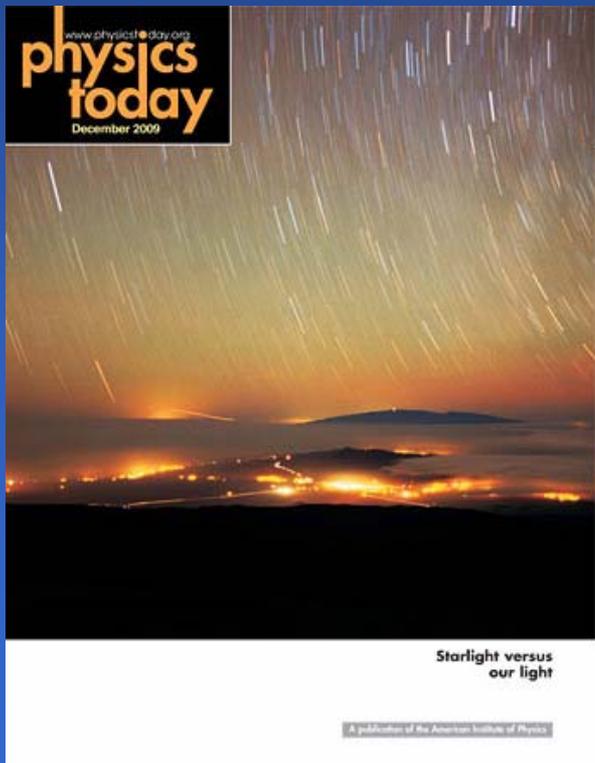
The Arizona Arts, Sciences, and Technology Academy commissioned the University of Arizona's Eller College of Management to study the economic impact of astronomy in Arizona.

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



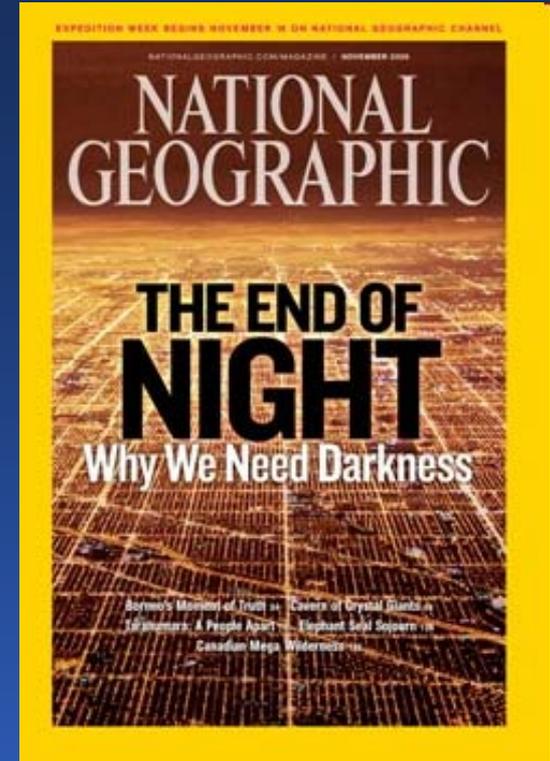
# Light Pollution

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



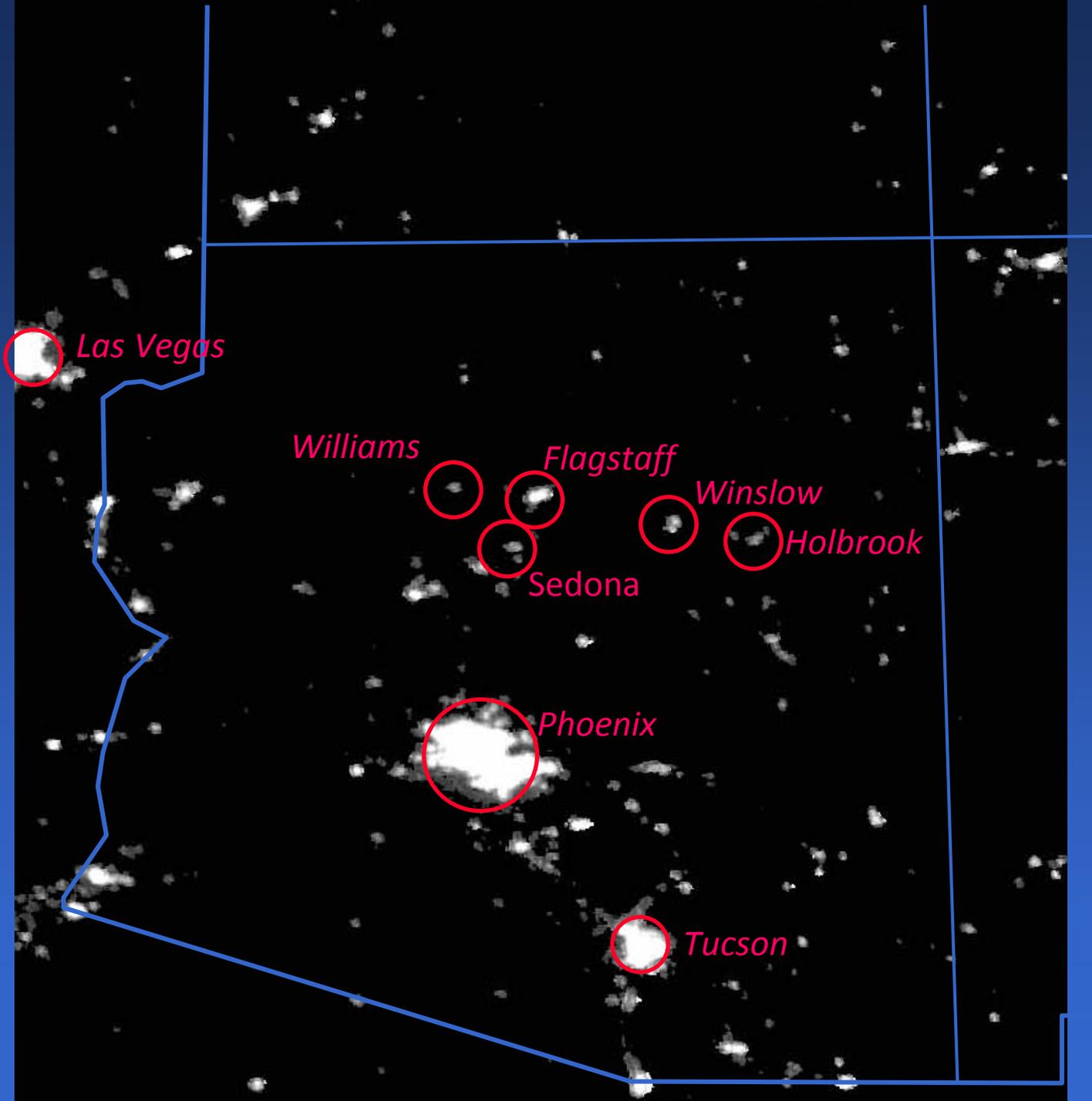
Feature article *Lighting and Astronomy*

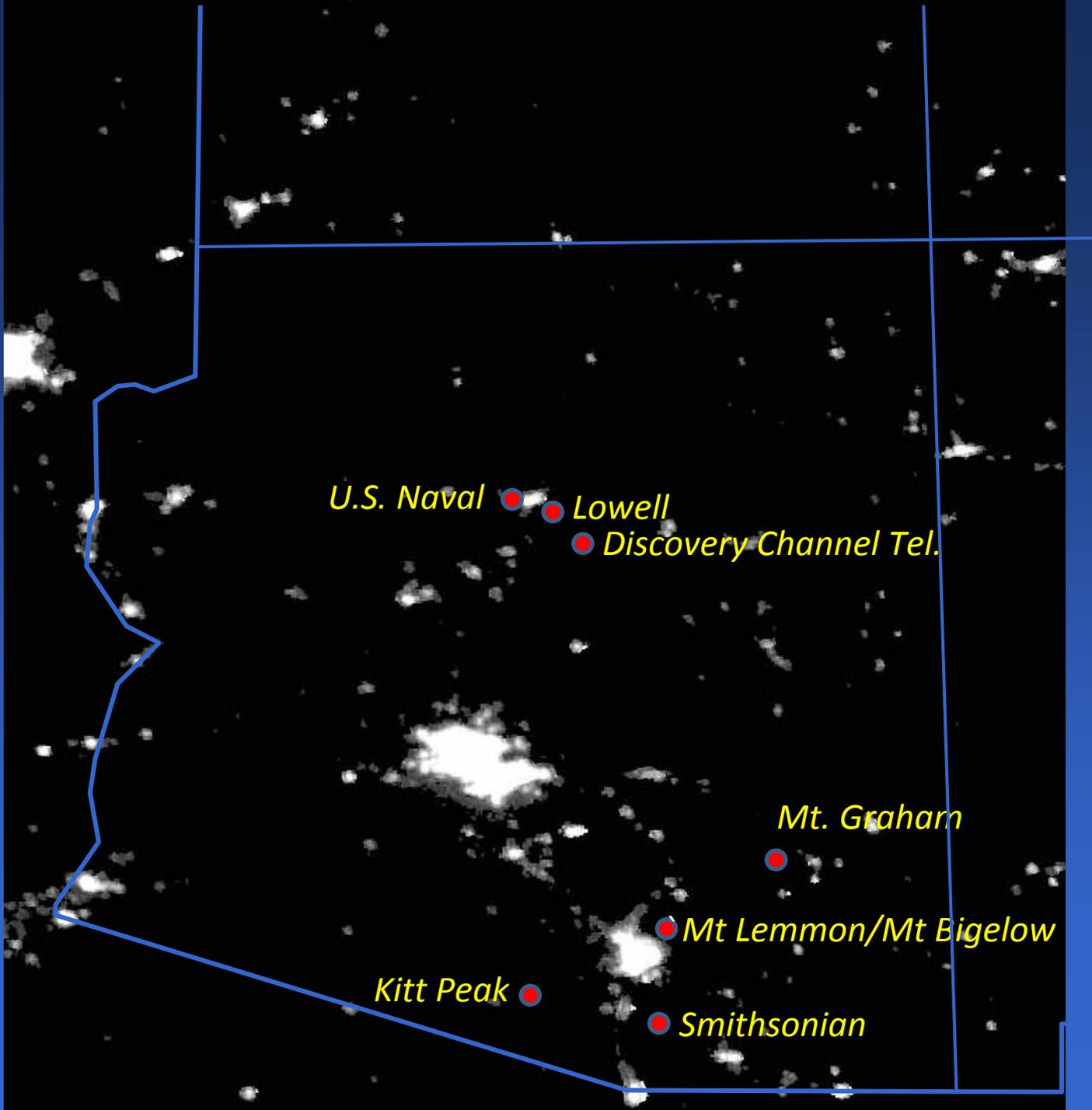
The rapid growth of light pollution threatens the future of astronomical observations.

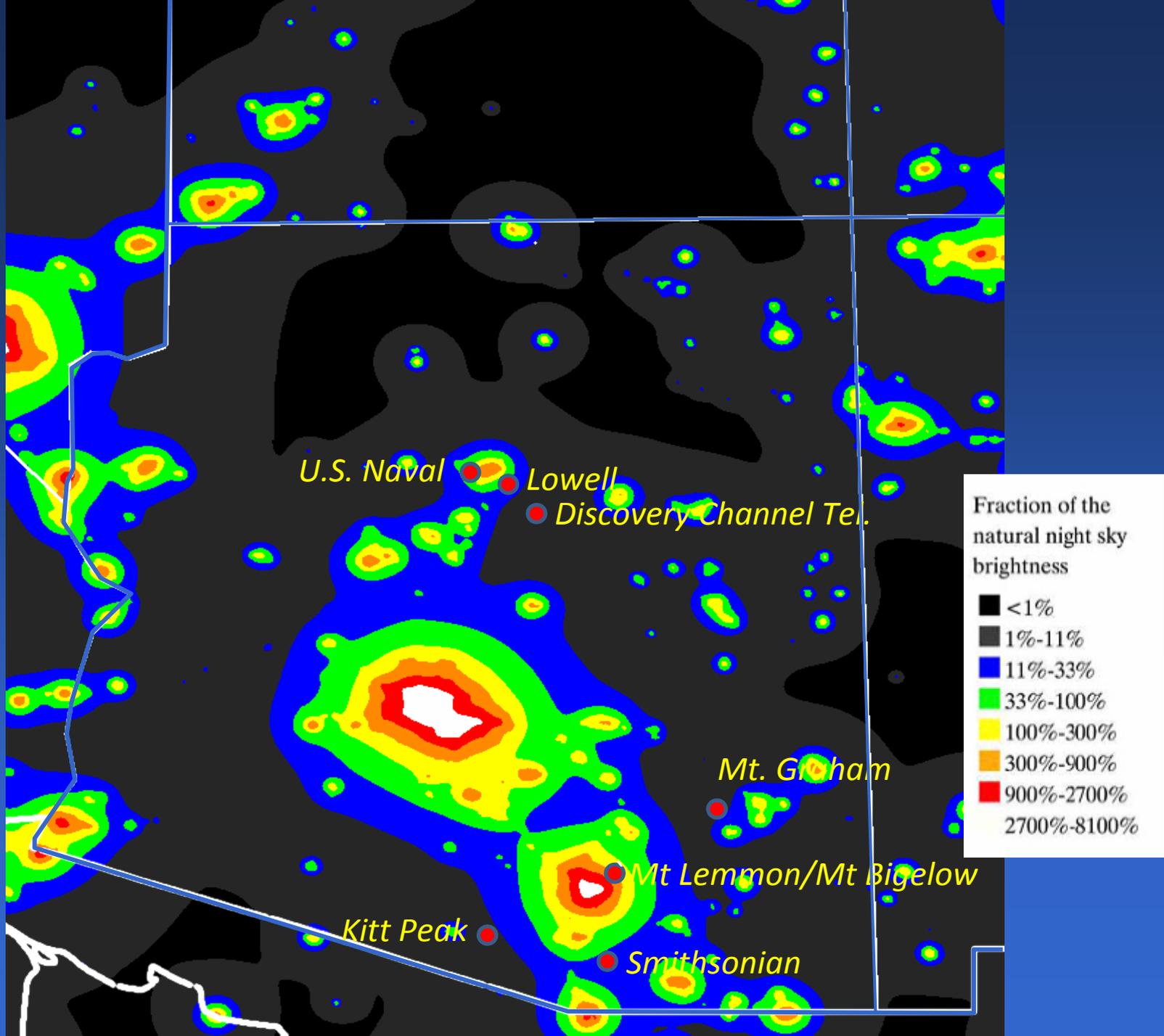


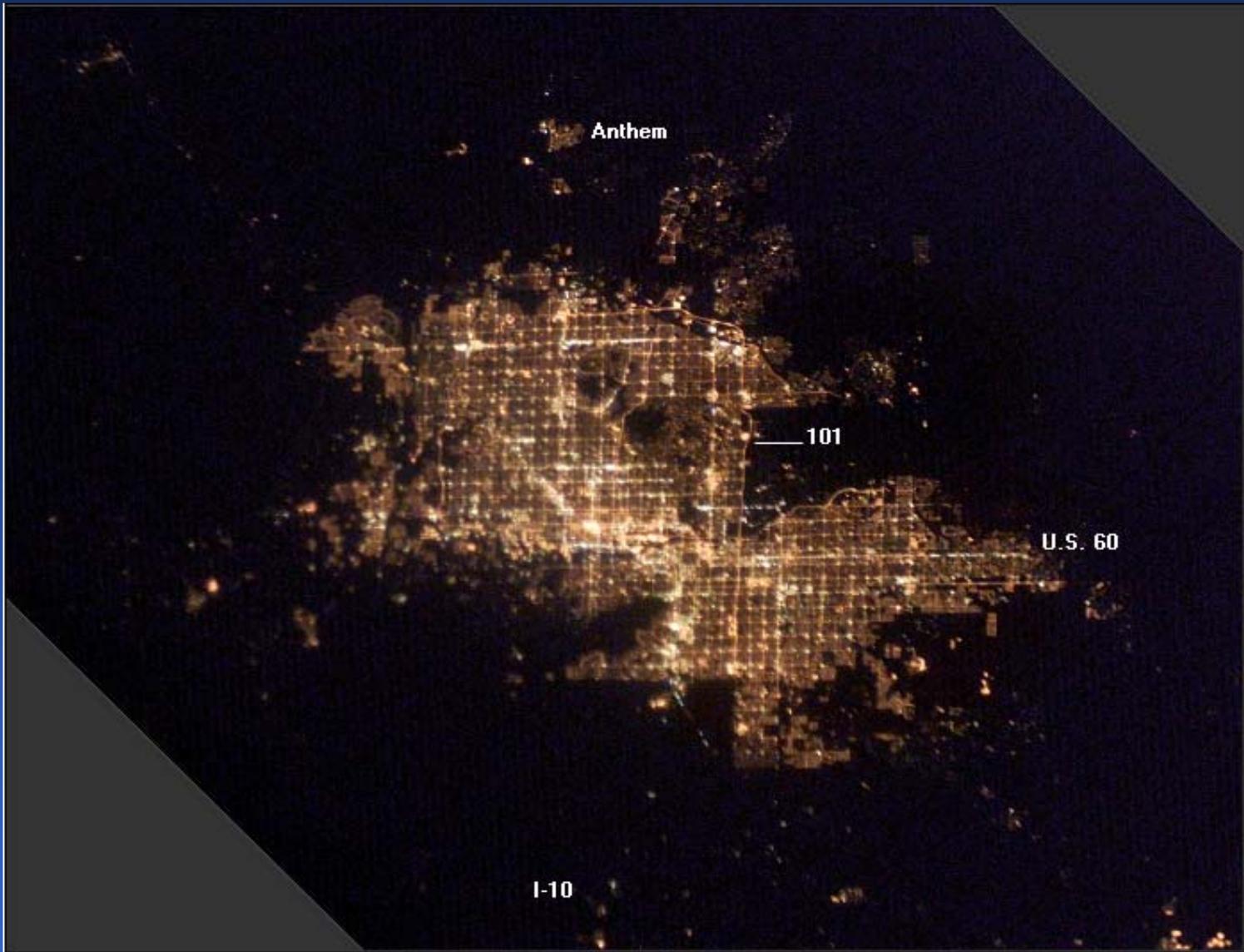
# North America at Night





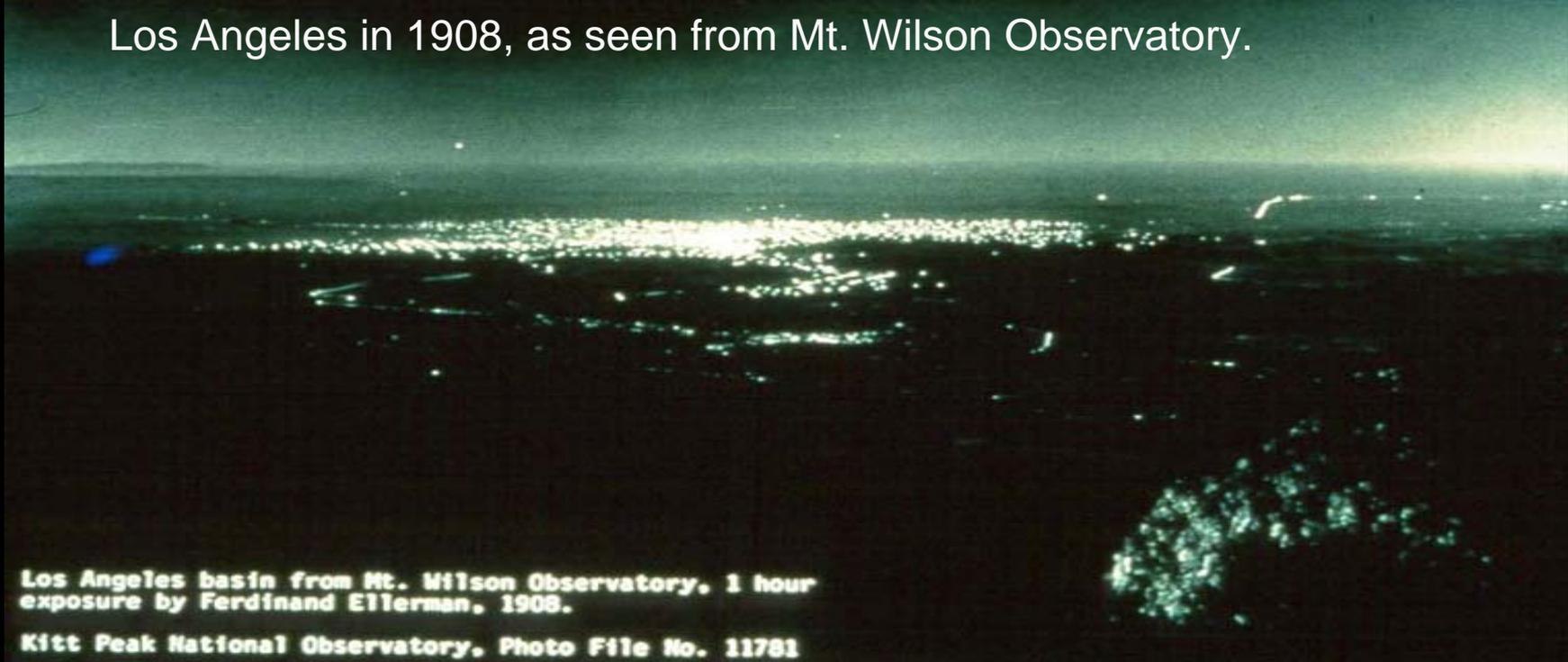






**Image of Phoenix at night taken from the International Space Station**  
(~220 miles above) (NASA, ISS CEO project)

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.





# 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.

## An Outdoor Lighting Code is not a Lights Out Code

- Outdoor lighting codes such as the MAG Draft Pattern Outdoor Lighting Code, v. 6, draft are sometimes called *dark sky codes*, but never *dark ground codes*.
  - A well-designed and enforced OLC makes the sky darker not the ground darker.
  - The purpose is to put light where it serves a useful purpose -- on the ground where it helps you see --and not in your eyes (glare) or in the sky (wasted).
- 
- This is the MAG Dark Sky Stakeholders Group, not the MAG *Dark Ground* or MAG *All Lights Out* Stakeholders Group.
  - The intent of an OLC is to provide quality lighting to improve visibility at night for everyone, save energy and thereby protect dark skies.

## Light Pollution and Human Health



Feb. 2008

### ***Turning Out the Lights The dangers of a bright night are becoming more apparent***

...  
But a brighter world, it is becoming increasingly clear, has its drawbacks. A study released last month finding that breast cancer is nearly twice as common in brightly lit communities as in dark ones only added to a growing body of evidence that artificial light threatens not just stargazing but also public health, wildlife, and possibly even safety.

American Medical Association, Resolution 516. 2009

### ***Advocating And Support For Light Pollution Control Efforts And Glare Reduction For Both Public Safety And Energy Savings***

...support efforts to ensure all future streetlights be of a fully shielded design or similar non-glare design to improve the safety of our roadways for all, ...

International Agency for Research on Cancer (IARC), the cancer research agency of the World Health Organization, 2007

Shiftwork that involves circadian disruption is “probably carcinogenic to humans.”

---

Circadian rhythm

Immunology impacts

Sleep disorders

A psycho-social stressor

Vision

The aging or disabled eye

Glare, Transition Adaptation

Luminance Overload

## Light Pollution and Wildlife

Birds   Amphibians   Mammals  
Reptiles   Insects



“A hallmark of every experimental organism from fruit flies to mice is that intense, constant light causes the normal circadian rhythm to go into arrhythmia, to essentially go whacko.”

– Michael Rosbash, Ph.D. Howard Hughes Medical Institute, HHMI Research News, March 2000



## Light Pollution & the Value of the Night Sky

National Park Service Night Sky Team  
(Monitoring Program)

International Dark-Sky Parks

Deed-restricted developments (Sky Village)

Astro Tourism (Ariz. Dept. of Tourism)

*Sunshine May Bring Travelers To Arizona, But It's The Dark Skies That Take Them To A New Dimension*

Phoenix (March 26, 2009)— Each year, millions of travelers from all over the world flock to Arizona to take advantage of the state's famously sunny skies. However, it's not until the skies go dark that the real fun begins.

Arizona is one of the country's top “dark sky” destinations, meaning that artificial light has not diminished the spectacular beauty of the night skies in most areas of the state. This gives travelers the increasingly rare opportunity to gaze up at an endless starry sky.

Opportunities for stargazing abound in Arizona from resorts astronomy programs and star parties to world-class observatories and twilight adventures. ...

# Light Pollution and Energy

Green Building Programs   Carbon foot print   Energy expense   Green Energy Codes

An example: *Municipal street lighting costs*

The City of Santa Rosa is implementing a citywide Street Light Reduction Program to cut energy costs and lower green house gas emissions. The Street Light Reduction Program will be implemented over a four year period from 2009-2012.



## Cost Savings and Environmental Benefits

We estimate the Street Light Reduction Program will result in an **annual energy cost savings of \$400,000**. The savings will be achieved by turning off some street lights, equipping some with programmable photocell timers, and leaving some lights to operate throughout the night.

Reducing energy consumption from street lights will result in a **significant reduction to the City's carbon footprint. An estimated 1,000 tons of greenhouse gas emissions will be reduced annually** through this program.

<http://ci.santa-rosa.ca.us/departments/publicworks/streetlightreduction/Pages/default.aspx>

# Code elements to promote good outdoor lighting

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

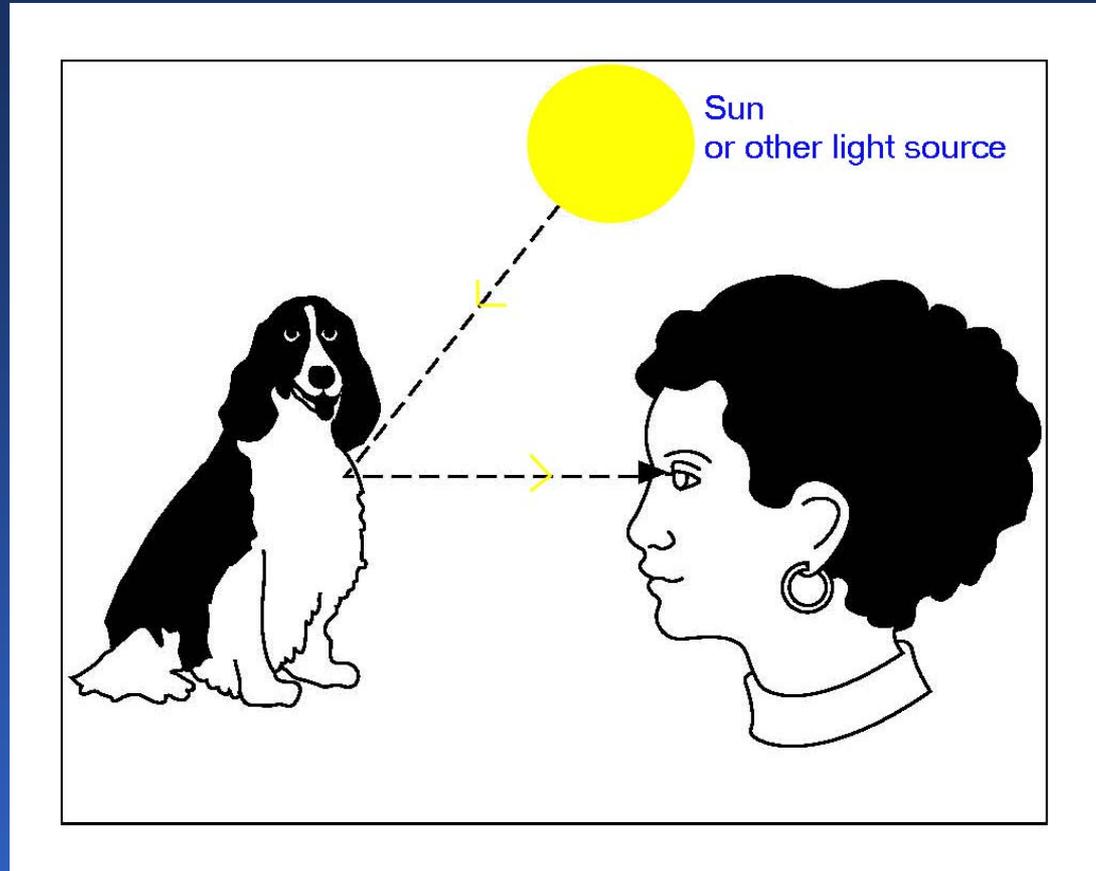
**Amount of light** -- prevent over-lighting with lumens limits

(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.



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 lighting fixture in the fog, showing the excellent control of light output.



# A full cutoff “shoe box” street or area lighting fixture



(Photos by H. Israel)

# The Biggest Complaints

- Too much light.
  - neighbor's lights.
- Glare.
  - Wall packs, “security” lights, floodlights.
- Can't see well anymore.
- Light trespass
- Not comfortable; it's obtrusive light.





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 numerous tall stadium light towers. The infield is a reddish-brown color, and the outfield is green. In the background, there are several large, modern-looking structures, possibly bleachers or a stadium, also illuminated. The sky is dark, and the overall scene is a well-lit sports facility 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.

# Prior Floodlighting



Photographs taken from Sentinel Peak (A. Mountain).  
Before and After photographs taken with same camera at same settings:  
Canon D2 camera with 200mm lens; shutter speed - 1/50 sec.; lens aperture - f/2.8; ISO - 2000

## Key Points:

- Over 100,000 watts in energy savings from prior lights – 500,000 kWh estimated reduction over next 25 years
- Increased on-field light levels by 25% to meet NCAA Best Practices for BCS competition levels
- Reduced measurable off-site spill light by 75%
- Improved uniformities on-field
- Eliminated maintenance costs for next 25 years

**25-Year Life-Cycle Savings: \$113,000**

### ARIZONA STADIUM, UNIVERSITY OF ARIZONA Tucson, AZ

125 constant horizontal/vertical footcandles; 1.5:1 uniformities

#### System Energy Consumption:

- |                                  |                            |
|----------------------------------|----------------------------|
| • Prior Floodlighting – 463.3 kW | • Musco Green™ – 362.8 kW  |
| 95 horizontal footcandles        | 125 horizontal footcandles |

# After Green Generation Lighting®



Musco Sports Lighting, LLC - Patents issued and pending - Savings based upon customer estimated usage of 200 hours per year at 10¢ per kWh, group relamping, and spot maintenance - 136920 - BP-6960-1

# 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

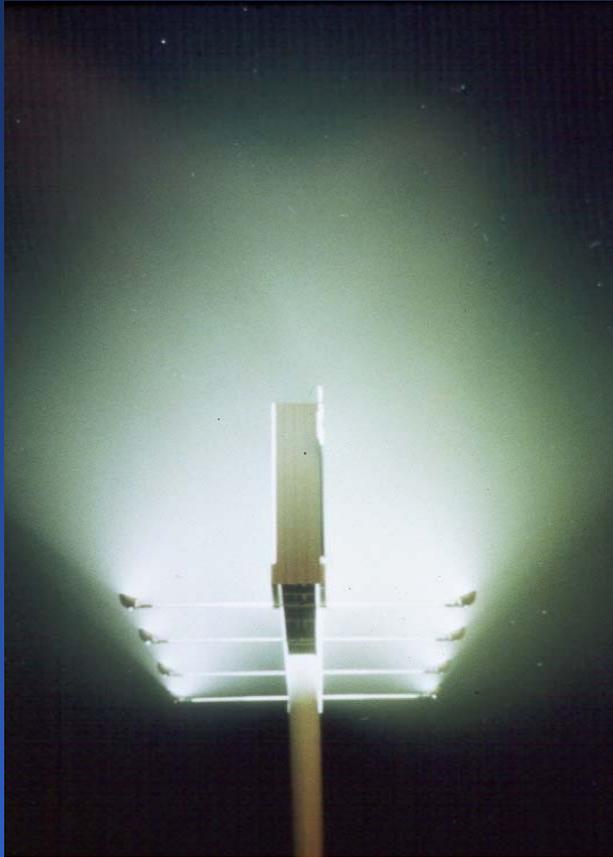
Type of light fixtures (full cut off)

How mounted? (top mounted)

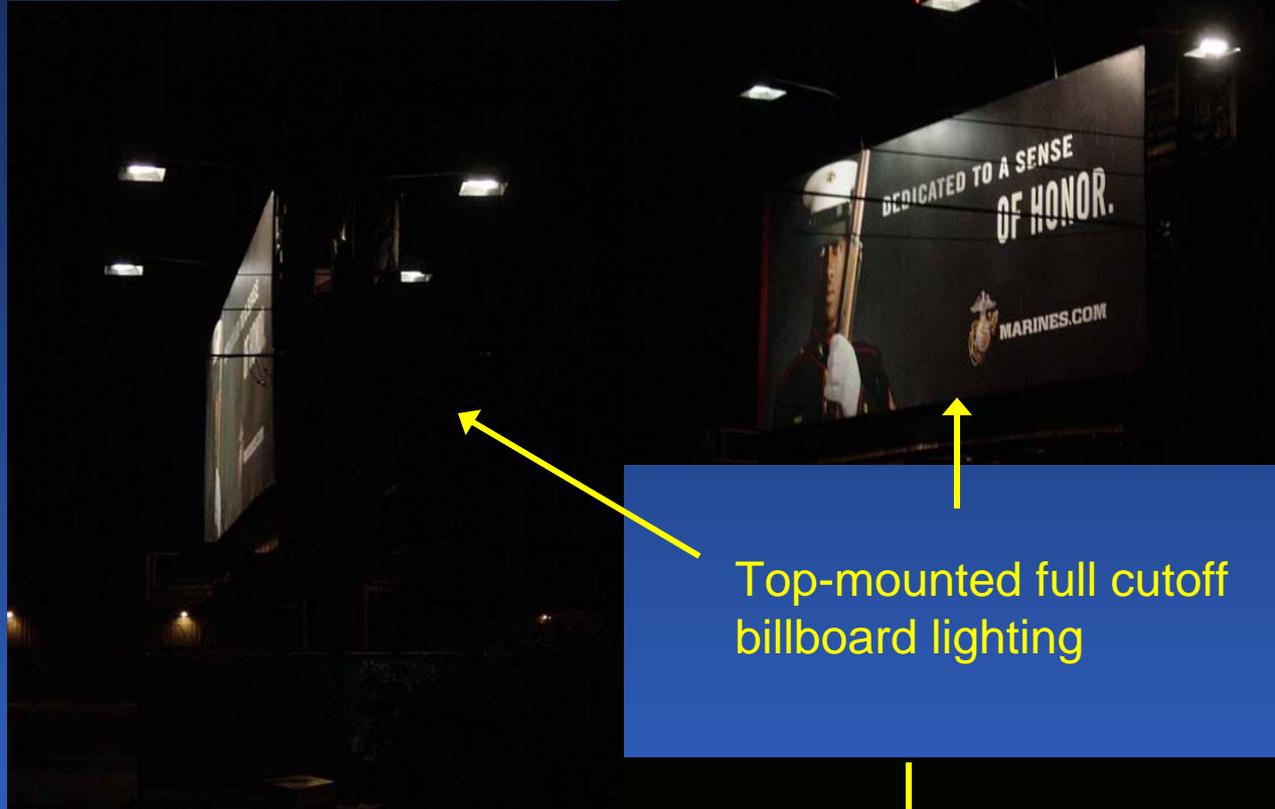
How much? (lumens limit)

How long is sign lit? (curfew)

## Externally illuminated signs



A bottom-lit billboard, seen from the side.



Top-mounted full cutoff billboard lighting

A top-lit billboard, seen from the side.



