Dark Sky Ordinances:
How to Separate the Light from the Darkness

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Executive Summary

In many areas of the United States it is difficult to view the stars in the sky at night. The International Dark Sky Association[2], has successfully lobbied state and local governments to pass restrictive ordinances on the type of lighting private property owners may use. These "Dark Sky laws" aim to reduce "light pollution" so as to make stargazing easier. Many of these laws, such as the City of Aspen's, impose unfairly short deadlines in forcing property owners to replace their current lighting. Excessively severe Dark Sky laws overlook the role that lighting plays in deterring crime.

States and localities should consider some key facts when studying dark sky legislation:

- Light is a good, not a form of pollution. Night-time lighting greatly expands human freedom of action.
- Urban lighting in the United States is not harming advanced astronomical research.
- Amateur astronomy is best conducted away from urban areas.
- Dark sky ordinances mainly benefit casual urban stargazers.
- Research shows that improved street lighting reduces crime by 20 percent.
- Retroactive ordinances are extremely costly and unfair to private property owners.
- There are many good Dark Skies laws which, imposed prospectively, can enhance stargazing without harming other interests. The final section of this Issue Paper provides some examples.

I. Lighting is a good, not a form of pollution

Advocates of harshly restrictive Dark Sky laws have invented the phrase "light pollution," a misleading term that should be banished from public discussion. Dioxin is a true pollutant; it is a by-product of certain industrial processes, and although the processes create useful goods, dioxin itself is of no value to any living creature. Dioxin is an unwanted, harmful, and useless waste product. So the phrase "dioxin pollution" makes sense.

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When people talk about "air pollution" or "water pollution", they are really talking about pollutants in the air or water; they are not claiming that air or water are themselves a form of pollution.

The term "light pollution" is premised on the mistaken idea that light itself is a form of pollution, rather than a positive good, like air and water. Light helps reduce crime and has allowed people in the twenty-first century—unlike their ancestors from darker ages—to continue reading, socializing, and engaging in other activities after the sun goes down. Man-made light allows more human choices and therefore more freedom.

As scientists have noted, most man-made light does not reproduce the full spectrum of solar light. It has been argued that people who get too much indoor light, and not enough sunlight, suffer from disruption of their natural body rhythms, thus interfering with the production of melatonin and of hormones, and possibly making themselves more vulnerable to cancer. Thus, some of the more extreme Dark Sky advocates, who want to drastically curtail man-made lighting, claim that they are doing people a favor. We disagree.

Adults are capable of making their own decisions about bedtime. If they choose not to stay up late, they have the right to do so. Only the most extreme form of an oppressive Nanny State would try to control people's bedtimes.[3]

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There are, however, many moderate and reasonable advocates of Dark Skies legislation, and they make some very good points. Throughout human history people have studied the heavens. To gaze at the moon and stars and planets is to look beyond the earth and beyond oneself—and for a moment, to forget oneself and thus to see everything else—to see the bigger picture of the wondrous universe.

If you learn at least a little astronomy, then you will have an easier time finding your way when you are lost, because you can find the North Star. You will know how to the tell the difference between the Winter Sky (featuring the clear, sharp light of Orion the Hunter in the southern sky) and the Summer Sky (featuring bright Vega and the Northern Cross arcing across the top of the sky). On moonless nights, you may see the Milky Way. For some people, the quiet reflective times of stargazing help them find their way when they are lost in a non-geographic sense. A child or an adult who is always inside watching television every evening is missing a much more important show outside in the sky.

Enjoying the Night Sky is not difficult for a beginner. Mercury, Venus, Mars, Jupiter, and Saturn are all visible to the naked eye, as are dozens of constellations. No matter what the time of year, there are always a few very bright stars which are easy to find and identify. With binoculars, a person can see moons of Jupiter, the rings of Saturn, the planets Uranus and Neptune, the closest galaxy (Andromeda), and beautiful details on the surface of Earth's moon.

So the proponents of Dark Sky laws are exactly right in their desire to preserve the opportunity for stargazing. However, the use of the phrase "light pollution" is dead wrong. Light, after all, is what

the star-gazers want to see—either direct light from stars, or sunlight which is reflected off a planet or moon.

Sometimes man-made light may overwhelm starlight, but this does not mean that man-made light is a pollutant simply because it is made by man, whereas starlight or moonlight is good just because is not man-made. First of all, man is part of nature, and therefore so is the light created by man. Anti-light extremists who argue that man-made lighting is a pollutant because it is unnatural would—if they were going to be consistent—never use eyeglasses, binoculars, or telescopes to stargaze. After all, eyes are "natural" and telescopes are artificial.

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So as we consider how to facilitate the viewing of the lights of the heavens, let us not make the mistake of considering the lights of the earth to be "pollution." Moonlight, starlight, and man-made light are all good, and a sensible policy will seek to harmonize their public uses, rather than imposing darkness for its own sake.

II. Urban lights in the United States are not affecting major astronomical research.

Starting from the earliest times when humans studied the stars, and continuing until a few hundred years ago, all scientific study of the stars was performed with the naked eye. Today, just about all the naked eye research which can be done has been done; the only significant contribution which a naked eye astronomer can make today is to report on the direction and number of meteors in his area during a meteor shower.

In 1609, Galileo invented the astronomical telescope. Within a few weeks, he discovered the mountains of the moon and the four largest moons of Jupiter, and found that the Milky Way was made of stars. Today, a few hundred dollars can buy a telescope much better than Galileo's. Ten thousand dollars can purchase an outstanding computerized telescope. But again, even the best of these amateur telescopes can only see objects almost all of which have already been carefully studied by professional astronomers.[4]

The telescopes used by Galileo and by modern backyard astronomers are optical telescopes; that is, they amplify light from visible spectrum. It is the optical telescope which is most at risk of interference from man-made terrestrial light.

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In the twentieth century, new scientific telescopes were invented which could receive and amplify waves from the non-optical portions of the electromagnetic spectrum. The most common such telescope is the radio telescope. Of course a radio telescope is not affected by street lights, but a radio telescope would be hindered by interference from radio signals.

Today, professional scientists use extremely large and high-powered telescopes which they place in very isolated locations—as far as possible from radio waves and street lights. The telescopes also are placed in elevated locations, to avoid distortions caused by the atmosphere.[5] Among the most important locations for modern scientific telescopes are Mauna Kea, Hawaii; Mount Hopkins, Arizona; and Cerro La Silla, Chile.[6]

Given the costs of producing these large telescopes, research universities have to pool their resources to fund construction. The University of Colorado's Center for Astrophysics and Space Astronomy has joined the Astrophysical Research Consortium, which built the Apace Point Observatory in Sunspot, New Mexico.[7]

Accordingly, there are only a few remote locations on earth where man-made light might interfere with the most advanced scientific research. There is no such location in Colorado. Only a few advanced research telescopes are near cities, such as the Kitt Peak telescope near Tucson, or the Mount Palomar telescope near San Diego.

Of course many universities in urban areas have their own observatories. The University of Colorado at Boulder and Denver University have on-campus observatories; both are often opened to the public for star-gazing events. The college observatories have powerful telescopes, but those telescopes are far less powerful than the advanced research telescopes in remote locations. Obviously the presence of urban light somewhat reduces the capabilities of the college campus telescopes. Indeed, if the cities of Denver and Boulder vanished, the light which is emitted just from the DU and CU campuses would be considered intolerable if the light were near one of the advanced research telescopes in Arizona or Hawaii.

However, a college which chooses to build a telescope on-campus is making a conscious trade-off. By being on campus, the telescope will necessarily be near man-made light; if the campus is located in an urban area, there will be even more man-made light. On the other hand, the urban college telescope is located conveniently to students, faculty, and people who live in the college town. Thus, the collegiate telescope can be used to educate many people.

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III. Serious amateur astronomy is best conducted away from urban and residential areas

As we have discussed above, almost anyone can be at least a casual astronomer, and we wish that almost everyone would. Among the people who know their way around the Night Sky, there is a subset of serious amateur astronomers. (Just as there is a large number of casual coin collectors—such as children who collect state quarters—and a much smaller group of serious collectors of rare coins.) High-quality modern amateur astronomical equipment is about a hundred times more light-sensitive than amateur equipment was several decades ago. So amateur astronomers have the ability to see very low magnitude objects under good viewing conditions.

Serious amateur astronomer organizations encourage their members to observe away from urban areas. StarDate Online, which is produced by the University of Texas McDonald Observatory, suggests stargazing "in remote rural areas, far from the lights of cities and towns." They also note that high altitude helps the view and therefore suggests viewing on top of a hill to avoid the turbulence of Earth's atmosphere.[8]

Instead of conducting stargazing sessions in suburbia or the cities, amateur astronomy groups often travel out to remote areas. For example, the Western Colorado Astronomy Club conducts viewing sessions on top of Blue Mesa, on the Rabbit Valley Overlook, and the Colorado National Monument.[9] The Denver Astronomical Society conducts "star parties" in a location near Byers.

Other than by returning to the Dark Ages, it would be impossible for any city to come close to matching the extremely low levels of man-made light which are found at amateur astronomy observation sessions. At star parties, cars are required to turn off their headlights. (Indeed, cars are one of the very major light sources in cities, and there is no current practical way to reduce headlight illumination without causing many more accidents.) Even ordinary flashlights are disfavored at star parties; participants instead use small flashlights which emit low levels of red light.

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IV. Dark Sky laws benefit mainly solitary, casual, residential stargazing

The main beneficiaries of dark sky ordinances are people who wish to view the night sky from their backyard. Anyone who does not study the Night Sky at least occasionally is missing an important part of the human experience.

A. All choices of a residence involve voluntary trade-offs

People always make trade-offs in their lives, and some trade-offs involve sacrificing one good in favor of other goods. If you choose to live in Hawaii, you will enjoy the abundant sunshine and water, but you should not complain that you cannot go ice-climbing. Similarly, if you choose to live in Manhattan, you can enjoy the ballet, the opera, the museums, the bookstores, the street scenes, and the millions of other special activities possible when millions of people live together in a compact area. But when you move to Manhattan, you should not complain that you cannot afford a large house with a half-acre yard, and you also should not complain that it is hard to see the Orion Nebula distinctly.

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We point out these obvious trade-offs because some Dark Sky advocates refuse to acknowledge them. There are Dark Sky advocates who complain about the Las Vegas Strip. To state the obvious, the Las Vegas Strip is no place for people who want to commune with nature. Just as a minority of people who eat organic food want to eliminate the "bad" choices of people who choose to eat highly processed food, some Dark Sky advocates seem determined to impose their low-light agenda everywhere—regardless of the interests and needs of other humans.

B. Dark Sky laws should not interfere with lifestyle choices

We favor reasonable Dark Sky ordinances because we want to encourage backyard astronomy. But we do not favor oppressive ordinances which violate the rights of other people. Simply because we believe (as does the Dark Sky Association) that stargazing is an especially important activity does not mean that we have the right to injure other people who do not feel the same way. In particular, we have no right to harm them financially, and no right to put them in danger of being attacked by a violent criminal. And we certainly have no right to try to limit their nighttime lighting because a scientist theorizes that people's natural circadian rhythms would be better served by going to bed at sunset.[10]

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C. Very dark skies are *not* necessary to encourage beginning astronomers

The brightness of a star is called the "magnitude." A star with a magnitude of 1 is 2.51 times brighter than a star with a magnitude of 2. A star with a magnitude of 2 is 2.51 times brighter than a star with a magnitude of 3. And so on. The limit of naked-eye visibility is about magnitude 5.5 or 6.

On a clear, moonless night on a mountain top in the countryside, when the atmosphere is perfectly still, a person with perfect vision can see about 2,500 or 3,000 stars. (A person in the southern hemisphere would see an equal number of different stars.) Under excellent but not perfect conditions (a clear night in the countryside at sea level) a person would see about 1,500 stars.

If a site's "limiting magnitude" is 5.5, there are about 800 visible stars. If the limiting magnitude is 5.0, about 400 stars would be visible.

Galileo's telescope enabled him to see about 30,000 stars. (Since the telescope allowed observation of

stars with magnitudes below the limits of naked eye visibility.) Using all of the world's best telescopes today, there about 70 sextillion (70,000,000,000,000,000,000,000) observable stars.

But to the extent that Dark Sky laws are primarily intended to nurture a child's sense of wonder in looking at the sky, the relevant form of observation is naked-eye observation.

For some types of naked-eye observation, darker is better, and pitch black is best of all. For example, even in a remote rural area, moonlight often washes out the Milky Way; so the Milky Way is best observed on a moonless night. The Milky Way is a beautiful and inspiring sight.

It also is a beautiful experience to go into the countryside and observe the canopy of 1,500-3,000 visible stars. One of the things that make the viewing so beautiful is that the view is overwhelming. Under optimal conditions, the sky appears quite dense with stars. Every child should see and appreciate this awesome view.

However, for the beginning or young astronomer, perfectly black conditions are not optimal. If one is going to learn the night sky, then one needs to learn to "navigate" the sky—to learn at least several constellations, and to be able to follow them as they cross the sky during the night. As one learns the constellations, one learns their seasonal cycles: Orion comes out the Winter, the Northern Cross in the summer, and the Big Dipper is out year-round, but changes position throughout the year.[11]

When one is learning the constellations, the 800 or 3,000-star night sky can be overwhelming. There are simply too many stars for most beginners to be able to sort out the constellations easily. Pristine viewing conditions can be an impediment.

The IDA's main justification for restrictions on night-time lighting is "for the children." If Dark Sky laws are really "for the children" (rather than for the dedicated hobbyist who is upset that he cannot see magnitude 11 stars in his telescope because of ambient urban light), then Dark Sky laws should focus mainly on preserving the night-time view of several hundred stars, rather than worrying about the visibility of magnitude 5.5 stars, which are a hindrance to the novice astronomer.

V. Examples of Stargazing under Varying Conditions

This section shows various views of the night sky, to illustrate how different conditions affect the number of visible stars. Colors in the illustrative figures are reversed, so that stars are dark, and the background sky is light.

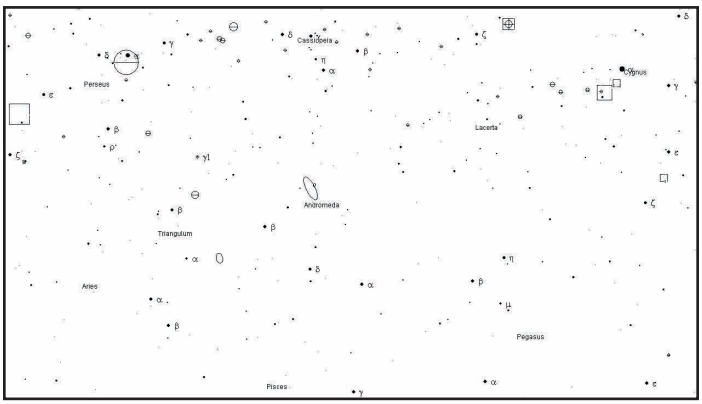

Figure 1. View from near Denver, on October 6, 2005, looking at the Zenith (straight up). The field of vision is 90 degrees wide. Stars of up to 5.5 magnitude are visible. Stars are represented as dots. Other objects (such as the Andromeda Galaxy, or nebulae) have different shapes. The Greek letters designate the major stars in each constellation. A view of the Zenith is generally superior to other views, because starlight travels through less of the Earth's atmosphere. Atmospheric fluctuations are what causes stars to appear to twinkle. The pictures in this section presume that the atmosphere is perfectly still.

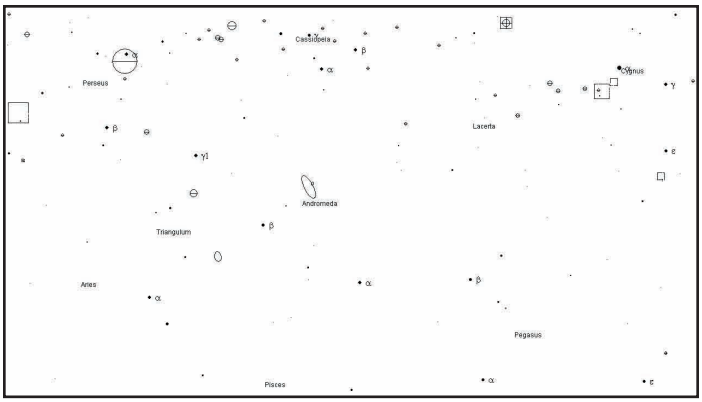

Figure 2. Same view. Stars of up to 4.5 magnitude. Fewer stars visible, due to moonlight, man-made light, or atmospheric turbulence.

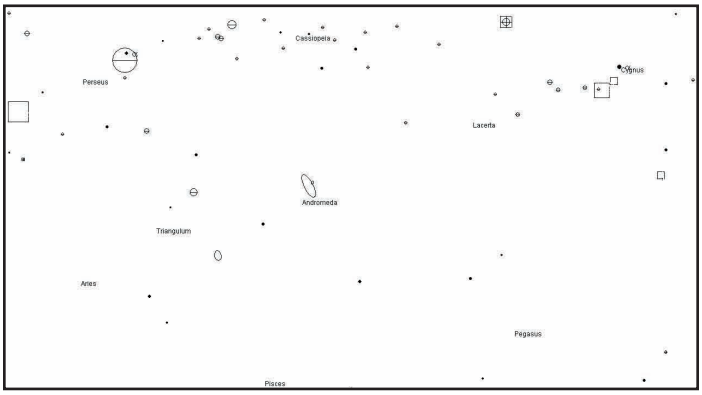

Figure 3. Same view. Only stars of 3.0 or brighter magnitude. Such a view could be the result of substantial interference from artificial light sources.

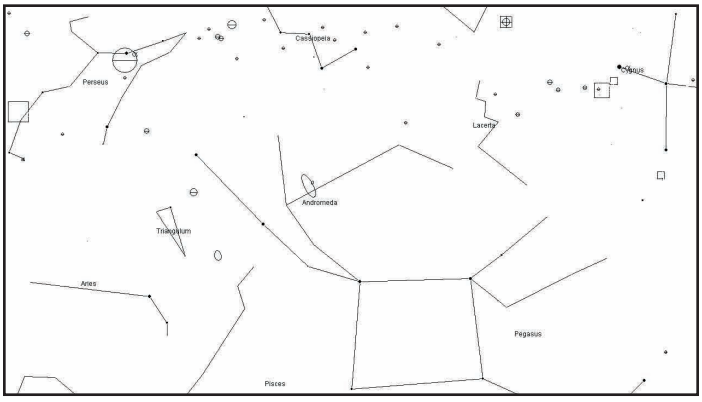

Figure 4. Same view. Stars up to 4.0 magnitude. Constellation lines included. The result of lesser interference from artificial light.

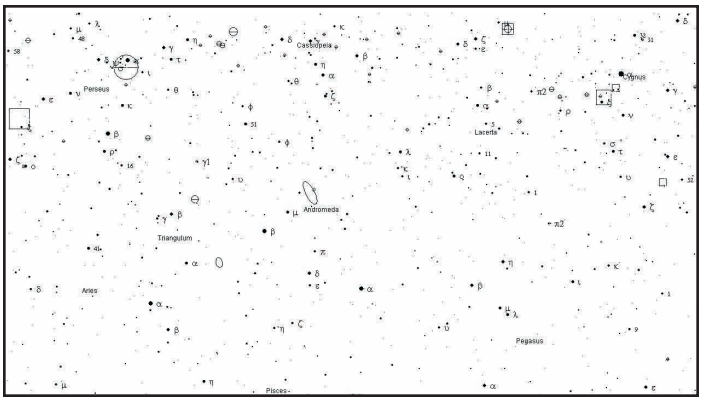

Figure 5. Same view. Stars up to 8.0 magnitude, which are visible with high-quality astronomical binoculars. Because a binoculars' field of vision is relatively narrow, a person could only see a small slice of this view at any given moment.

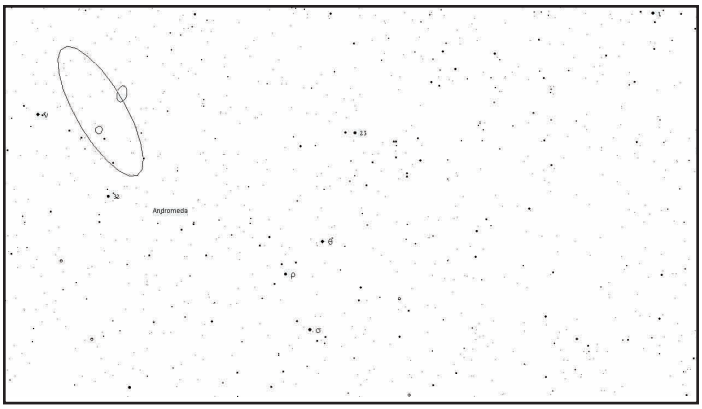

Figure 6. One sixth (15 degrees wide) of the above view, showing stars up to magnitude 10, which are visible with a fairly expensive amateur telescope. A person using a telescope would not actually see such a view, because a telescope has a very narrow field of vision, approximately one degree. With the telescope, many areas of the sky would appear completely blank. Typically, an amateur astronomer with a powerful telescope would examine a single star (or perhaps a double star) or other sky object.

VI. Improved street lighting reduces crime by 20% and enhances feelings of security

As long as humans have been keeping records of crime, there has been more crime at night-time than in the day-time.

In an 1885 U.S. Supreme Court case, Justice Harlan noted the importance of public street lighting for public safety:

> An English historian, contrasting the London of his day with the London of the time when its streets, supplied only with oil-lamps, were scenes of nightly robberies, says that "the adventurers in gas-lights did more for the prevention of crime than the government had done since the days of Alfred." [12]

A. Older and inconclusive articles

The IDA claims that there is no relation between increasing the amount of light and reducing crime. The IDA points to two studies by the U.S. Department of Justice and the National Institute of Justice that supposedly did not find conclusive evidence of a link between improved lighting and crime reduction.[13] The IDA's claims are overstated:

- The Department of Justice (DOJ) and the National Institute of Justice (NIJ) did not conduct studies, but instead reviewed already existing studies.
- Neither the 1977 DOJ review nor the 1997 NIJ review denied that improved lighting may lower crime rates
- Many studies noted within these reviews *did find* a relationship between better lighting and reduced crime
- The National Institute of Justice "study" cited by IDA is merely a single page in a 469-page book on a wide variety of crime reduction techniques.

The 1977 Department of Justice project reviewed sixty studies of lighting and crime and found no conclusive pattern.[14] In 1997 the National Institute of Justice updated the 1977 review; the 1997 review noted that a 1994 study in Scotland found that relighting in a Glasgow neighborhood resulted in a short term "reduction in victimizations that varied from 32 to 68 percent" and that the overall crime rate dropped 14 percent.[15] Another study conducted in 1994 found that lighting improvements in three areas of London resulted in "Substantial reductions in robberies, auto crimes, and threats" in two sites and the complete elimination of those crimes in the third site.[16] However, the 1997 NIJ author discounted the London and Scottish studies because they had not included a control area (a similar area where there was no change in lighting). Relying on the 1977 DOJ article, the 1997 NIJ review restated the old conclusions.

B. Recent scholarship

Research in the area of lighting and crime has continued since the summaries reported by the IDA. In 1999, criminologists David P. Farrington and Brandon C. Welsh analyzed eight American studies and five British ones. They concluded that "the capacity of street lighting to influence crime has now been satisfactorily settled."[17]

The Farrington-Welsh analysis finds that "the overall reduction in crime after improved lighting was 20% in experimental areas compared with control areas."[18]

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Farrington and Welsh explain that "Street lighting benefits the whole neighborhood rather than particular individuals or households...In short, improved street lighting seems to have no negative effects and demonstrated benefits for law-abiding citizens."[19] The National Crime Prevention Council also concludes that lighting has a crime deterrent effect and increases detection of crime.[20]

Thus, street lighting is an especially beneficial form of crime prevention. Burglar alarms, for example, do reduce burglary of homes with installed alarms,

but do not reduce the overall burglary rate in a neighborhood.[21] Burglar alarms impose a substantial burden on the community, because the vast majority of alarms are false alarms, which waste police resources.[22]

The recent Farrington-Welsh article clearly supersedes the older, agnostic reports by the DOJ and the NIJ. Farrington and Welsh use more recent research. Unlike some of the studies which were discounted by the NIJ, the Farrington-Welsh analysis did use control areas.

In the world of public policy, a twenty percent reduction in crime is *enormous*. There are hardly any crime-reduction strategies for which even the most optimistic advocates can point to research showing a twenty percent reduction.

C. Enhanced feelings of safety

Not even the most fervent Dark Sky advocates deny that the public feels safer when there is sufficient street lighting. Even the older research cited by IDA concluded the public feels safer with sufficient lighting.

Lighting in public areas encourages people to come out at night. Many local communities and universities light up common walkways so as to create more inviting, safer-feeling spaces. Vulnerable people are especially comfortable in lighted areas.

Now, the Farrington-Welsh research has confirmed the common sense of the public. The reason the public feels safer when lighting conditions are good is because the public is safer.

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Thus, when overly restrictive Dark Sky laws degrade the quality of street lighting, they promote violent crime. Less street lighting means more rapes, more assaults, more robberies, and more murders.

It is wonderful to be able to see the details of the Crab Nebula from your back yard. It is also wonderful to be able to walk down the street without being attacked by a violent predator. Sensible, moderate laws about Dark Skies can help casual astronomers without endangering the public.

VII. Some Dark Sky laws are extremely costly and unfair to private property owners

Dark sky ordinances can impose a substantial cost on landowners, business owners, and city and state governments. Consider, for example, a proposed ordinance in Durango, Colorado.

A local businessman who runs four Exxon stations calculated that the cost of complying with the ordinance would be $50,000—an enormous expense for a small businessman.[23] The cost of fixing one middle school in Durango was estimated to be $20,000—a huge capital cost for a typical public school.[24] Dark Sky laws should consider the cost to residents and businesses.

Dark sky ordinances can impose a substantial cost on landowners, business owners, and city and state governments.

A. Prospective laws

Laws which require businesses and homes to retrofit existing lights are unfair. If a property owner has installed lights in compliance with all existing zoning and other laws, it is wrong for the government to suddenly force her to spend thousands of dollars because the government decides it prefers a new form of lighting.

A better approach can be found in the 2001 State of Colorado law which requires all outdoor lighting fixtures funded by the state after July 1, 2002, to meet listed requirements.[25] This forward-looking legislation is the best solution. Prospective legislation stops the problem from becoming worse, since new lighting will be installed to meet the new standards. Property owners are not forced to tear out existing lights.

Over time, most lighting fixtures are replaced. So

a prospective law ensures that eventually almost all the lights in a jurisdiction will meet the new standards. A prospective Dark Skies law follows the same policy as that of the Americans with Disabilities Act. Existing businesses were not suddenly required to install elevators or other accessibility improvements; however, high standards of accessibility were imposed on new construction and on major renovations.

B. Boulder's retroactive ordinance

In Boulder, the city's Dark Skies ordinance requires that current lighting fixtures be modified to meeting the revised standards within fifteen years.[26] The compliance period is relatively long, but any requirement for retrofitting is unfair. Doubtless, many big businesses will buy new lights anyway in the next fifteen years; but some small businesses may be forced to spend thousands and thousands of dollars to replace construction which they installed in full compliance with Boulder's already arcane and rigorous zoning laws.

If Dark Skies, are, like public parks, a public good, then the public should pay for them. It would be wrong for a city government to take someone's land without compensation in order to create a park for the public.

If darkening the skies of Boulder (or some other city) is really so important that existing lighting fixtures should be ripped out and replaced, the proper approach would be for the city to pay compensation to property owners for the taking of their property. If Dark Skies, are, like public parks, a public good, then the public should pay for them. It would be wrong for a city government to take someone's land without compensation in order to create a park for the public. Likewise, it is wrong for a government to require a person to eliminate his lawful lighting property, with no compensation, in order to create Dark Skies for the public. [27]

C. Aspen's awful ordinance

Section 26.575.150 of the Code of the City of Aspen required that all light sources conform within one year of passage. This extremely short compliance period was very harsh on property owners, because it mandated that lighting fixtures be replaced long before the ordinary replacement cycle.

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Boulder is hardly known as a town in which property rights are of much concern to the local government. Yet even in the town nicknamed "the People's Republic," property owners were given a fifteen year window.

Moreover, some of the asserted rationales for Aspen's oppressive ordinance were ridiculous. For example, the ordinance asserted the legislative purpose of "eliminating the escalation of night-time light pollution." Eliminating the "escalation" of night-time light "pollution" could be accomplished solely by imposing new standards prospectively on future light fixtures—rather than by retroactively requiring replacement of existing light fixtures.

The Aspen city council also asserted that the ordinance would prevent the loss of "small town character."[28] One might think that Aspen's "small town character" is already preserved by zoning laws which make additional density and expansion nearly impossible.

Moreover, it is absurd to contend that "small-town character" really depends on the kind of stargazing distinctions which are preserved by the Aspen ordinance. The North Star (Polaris) is the last star on the handle of the Little Dipper constellation. The constellation consists of three stars in the handle, and four on the cup. Two of the stars in the cup have a nearby, dim star, and these dim stars are also part of the constellation. (The dim stars are magnitude 5.2 and 5.5.) Does Aspen's small-town feel really

depend on whether one can see the "extra" stars in the Little Dipper? On whether Aspen's night-time sky consists of 600 stars or 900?

A sky with 900 stars looks nicer than a sky with 600, but it hardly has much to do with small-town feel. Small towns above the Arctic Circle have nearly perpetual sunlight in the summer, but it would be ludicrous to claim that those towns lose their small-town feel because no stars are visible.

If encouraging a small-town sense of community is the goal of the ordinance, then Aspen should organize community night sky viewings ("star parties"). Star parties would encourage a sense of community and enhance a small town character by encouraging neighbors to stargaze together instead of alone in their backyards. The communal stargazing could take place in mountain parks near Aspen, and be led by astronomy professors or experienced amateur astronomers. Children could also be encouraged to go to these areas with their families and see more distant and fascinating elements of the night sky.

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Meteor showers are often popular events to bring a community together.[29] The astronomy department at the University of Virginia has successfully held meteor shower viewings for residents of Charlottesville, Virginia, which were well attended.[30]

Legislation promoting and providing the small amount of money required to conduct these events would better serve to increase the community spirit as well as appreciation for the night sky.

Aspen's ordinance does evoke one type of small-town atmosphere: the small town depicted in Shirley Jackson's short story "The Lottery." This time, it is the homeowners and businesses which are selected for the ritual stoning—in order to affirm the city council's self-righteousness.

Another problem with the Aspen statute is its limitations on security lighting. Because research has shown that lighting can reduce crime, it is troubling that the statute imposes restrictions on how security lighting is used. If these restrictions lower the efficacy of security lighting, the restrictions would contravene the ordinance's primary goal to "promote safety and security."

Thus, Aspen should consider focusing its enforcement power on lights installed after the ordinance and should reduce regulations of security lighting.

Aspen's retroactive ordinance is an unfair violation of property rights, which the Colorado Constitution guarantees are the right of every person in Colorado, no matter where she lives. Just as the Colorado legislature in 2004 enacted remedial legislation to prevent some municipal abuses of the eminent domain power, the legislature should consider legislation to preempt abuse of property rights via municipal Dark Sky ordinances. When the ordinance has the effect of facilitating major violent felonies (surely a problem of statewide concern), then the need for preemption is all the greater.

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VIII. Guidelines for Dark Sky laws

- Do not impose requirements retroactively. Requirements for particular types of lighting should apply to new construction, or when old construction is renovated.

- Encourage retrofits of existing property through tax incentives, or by using public moneys to pay the cost directly.

- Laws should not grant the government a special exemption from the laws applicable to ordinary homes and businesses. If a particular government building has special security needs which necessitate extra lighting, the law should

also allow extra lighting for private properties which have special security needs.

- Light poles should direct most of their light downward, not wasting light into the sky. Some designs point down directly. Other designs use a reflective hood (known as a "shoebox") above the bulb, to bounce the light down. Municipalities should use such designs, which save energy and costs in the long run.

Policymakers should, however, recognize that "full cut off" (no light above the horizontal plane of the bulb) can make energy use less efficient. When a light pole uses full cut off (as opposed to regular "cut off" or "semi-cut off"), then the pole radiates very little light laterally (that is, 0 to 10 degrees below the horizontal plane). As a result, the pole illuminates a significantly smaller area of the ground. Thus, if a parking lot owner wants to cover the entire lot with at least some light, and municipal regulations force the owner to use full cut off shields on the light poles, then the parking lot owner will have to use more poles, which will be spaced relatively closer together. As a result, more electricity will be used to illuminate the parking lot. So the aesthetic environmental gain (no upward light from the parking lot) must be balanced against the environmental loss (more energy used). And the extra electricity expense imposed on the parking lot owner (and, necessarily, on the customers of the parking lot) must be considered.

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Policy makers should also understand that even full cut off will not eliminate all sky glow, because some downward-directed light will bounce off the ground, or bounce off reflective objects (such as the metal and glass on automobiles) and then travel into the sky.

- So as a general policy, lighting should be directed downward, rather than radiating in all directions, but there must be adaptations for particular circumstances. For example, if the lighting is covered by a roof or other structure which shields the sky from the light, then the lighting can project upwards.

- Free-standing lights can be limited to a particular height (such as 25 feet), or the height of the building on the property they occupy.

So as a general policy, lighting should be directed downward, rather than radiating in all directions, but there must be adaptations for particular circumstances.

- New billboards should have their lights pointing down from the top, not up from the bottom. After midnight, if the billboard is not advertising a business which is open after midnight, billboard owners should voluntarily turn the signs off.

- Display lighting (as opposed to security lighting) should be turned off at a set time after the store is closed at night.

- Huge light projections—such as from car dealerships—that travel far beyond the commercial property from which they originate can be limited to use at particular times, and in particular directions. There is no problem about applying such regulations to existing advertising, because the government would not be requiring the advertiser to spend money to change the equipment. Rather, regulation of long-distance light is similar to regulation of sound trucks or bullhorns. Reasonable time, place, and manner regulations protect the public from annoyance.

- Some security lights, depending on the particular needs of an area, can be set so that they are only activated by motion detectors, and will automatically turn off after a particular period of time.

- The International Dark Sky Association provides a list of outdoor lighting fixtures

which minimize upward escape of light. www.darksky.org/fixtures/fixtures.html. The website of the Illuminating Engineering Society of North America, www.iesna.org, also has a great deal of information about lighting issues although, unfortunately, much of the material is available only to members.

- Property-owners very near astronomy research facilities should consider the use of low pressure sodium lights (LPS), because LPS light is emitted in a narrow wave spectrum; as a result, telescope filters have an easy time blocking out LPS light. LPS lights should not be encouraged for general use, because their color is sometimes difficult to distinguish from a yellow traffic light. Moreover, LPS lights require a large lamp, and the light distribution is consequently more difficult to control.

The above list of ideas is not a full catalogue of reasonable Dark Skies laws. But it is a good starting point, and it shows that there are many ways to protect the important interests of people who love viewing the beautiful night sky, while also protecting the safety, property, and liberty interests of everyone else.

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ADDITIONAL RESOURCES on this subject can be found at: http://www.IndependenceInstitute.org or by contacting the following organizations:

Endnotes

[1] Michael Loatman is a candidate for a Juris Doctor degree at the University of Virginia School of Law. David B. Kopel is Research Director of the Independence Institute. Both Loatman and Kopel are amateur astronomers. We would like to thank Brian Barnett, Clayton Cramer, Michael King, Alberto C. Sadun, and commenters from the Volokh Conspiracy weblog (www.volokh.com) for helpful suggestions. The opinions in this article are those of the authors alone, and any errors are their responsibility.

[2] Their website is http://www.darksky.org.

[3] Some of the people who hope to use Dark Skies laws to encourage other people to go to bed earlier are rather hypocritical, since amateur astronomers often stay awake so they can work in the darkest period of the night.

[4] Comets would be among the exceptions, since some comets have not been visible from the earth in the era of powerful telescopes.

[5] Even a still atmosphere will somewhat interfere with the telescope's reception.

[6] A list of the world's largest telescopes can be found at http://www.seds.org/billa/bigeyes.html.

[7] Center for Astrophysics and Space Astronomy. "The FUSE Mission." http://casa.colorado.edu/ResearchProjects/arc/. Other participating universities include the University of Colorado, the University of Chicago, the Institute for Advanced Study (a private organization in Princeton, New Jersey), Johns Hopkins University, New Mexico State University, Princeton University, the University of Washington, and Washington State University. No significant optical telescope research is performed in the United States east of the Mississippi River.

[8] StarDate Online. "How do I find a good site for stargazing?" http://stardate.org/resources/faqs/faq.php?id=62

[9] Western Colorado Astronomy Club. "Maps" http://www.coloradowestastronomy.org/cnmmap.html

[10] One topic not addressed in this Issue Paper is a property owner casting unwanted light onto someone else's property. If you enjoy your dark backyard at night, your enjoyment may be lessened by light from your neighbor's floodlights which intrudes into your yard. Such an intrusion is a form of trespass, and a legitimate such for government regulation. But the topic is beyond the sky-centric focus of this Issue Paper.

Another topic not addressed in this Issue Paper is lighting control to protect wildlife. For example, sea turtles find their way to the ocean by looking for light reflecting off the water. Artificial lighting on beachfronts can confuse the nesting and movement habits of turtles. See http//www.turtles.org/threats.htm. For more, see Catherine Rich & Travis Longcore, eds., *Ecological Consequences fo Artificial Night Lighting* (Wash.,D.C.: Island Pr., 2005).

[11] To be precise, the Big Dipper is an "asterism" (a sub-unit) of the constellation Ursa Major (the Great Bear) and the Northern Cross is an asterism of Cygnus (the Swan). And to be more precise, all the visible stars rotate around the North Star, just as hands rotate around the center of a clock. So when we say that the Big Dipper is, for example, below and to the left of the North Star, we mean that it is below and to the left of the North Star in the evenings at certain times of the year. At other times of the year, when Big Dipper is below and to the left of the North Star during its daily rotation, the sun is out, so all the stars are invisible.

[12] *New Orleans Gas-Light Co. v. Louisiana Light & Heat Producing & Manuf'g Co. and others* 115 U.S. 650, 658 (1885), citing 7 Knight, c. 21. Also citing Thomas Babbington Macaulay, *The History of England from the Accession of James II*, volume 1, chapter 3, which states:

> It ought to be noticed that, in the last year of the reign of Charles the Second [1685], began a great change in the police of London, a change which has perhaps added as much to the happiness of the body of the people as revolutions of much greater fame. An ingenious projector, named Edward Heming, obtained letters patent conveying to him, for a term of years, the exclusive right of lighting up London. He undertook, for a moderate consideration, to place a light before every tenth door, on moonless nights, from Michaelmas to Lady Day, and from six to twelve of the clock. Those who now see the capital all the year round, from dusk to dawn, blazing with a splendour beside which the illuminations for La Hogue and Blenheim would have looked pale, may perhaps smile to think of Heming's lanterns, which glimmered feebly before one house in ten during a small part of one night in three. But such was not the feeling of his contemporaries. His scheme was enthusiastically applauded, and furiously attacked. The friends of improvement extolled him as the greatest of all the benefactors of his city. What, they asked, were the

> boasted inventions of Archimedes, when compared with the achievement of the man who had turned the nocturnal shades into noon-day? In spite of these eloquent eulogies the cause of darkness was not left undefended. There were fools in that age who opposed the introduction of what was called the new light as strenuously as fools in our age have opposed the introduction of vaccination and railroads, as strenuously as the fools of an age anterior to the dawn of history doubtless opposed the introduction of the plough and of alphabetical writing. Many years after the date of Heming's patent there were extensive districts in which no lamp was seen.

For more on the expanding mandate for street lighting in London as a result of crime control concerns, see J.M. Beattie, *Policing and Punishment in London: 1660-1750* (N.Y.: Oxford Univ. Pr., 2001), pp. 207-25.

[13] International Dark Sky Association. "An Introduction to the Issues of Light Pollution." http://www.darksky.org/handouts/bc_intro_lp.pdf

[14] Lawrence W. Sherman, et al. *Preventing Crime: What Works, What Doesn't, What's Promising*, National Institute of Justice, http://www.ncjrs.org/works/wholedoc.htm

[15] Id.

[16] Id.

[17] Brandon C. Welsh, & David P. Farrington, *Effects of Improved Street Lighting on Crime: Protocol for a Systemic Review*. http://www.aic.gov.au/campbellcj/reviews/2003-11-StreetLighting.pdf

[18] David P Farrington & Brandon C. Welsh, "Improved Street Lighting and Crime Prevention," 19 *Justice Quarterly* 313 (no. 2, June 2002).

[19] David P. Farrington & Brandon C. Welsh, *Effects of improved street lighting on crime: a systematic review*. http://www.homeoffice.gov.uk/rds/pdfs2/hors251.pdf

[20] National Crime Prevention Council, *Lighting Up for Crime Prevention* http://www.ncpc.org/ncpc/ncpc/?pg=2088-8888

[21] Terance D. Miethe, "Citizen-Based Crime Control Activity and Victimization Risks: An Examination of Displacement and Free-Rider Effects," 29 *Criminology* 419 (1991).

[22] Simon Hakim et al., "Estimation of Net Benefits of Residential Electronic Security," 13 *Justice Quarterly* 153, 161 (1996).

[23] Patricia Miller, "City officials hear comments on dark skies", *Durango Herald* http://durangoherald.com/asp-bin/article_generation.asp?article_type=news&article_path=/news/04/news040212_2.htm

[24] Id.

[25] See Colo. Rev. Stats. §§ 24-82-901 & 902.

[26] City of Boulder. "Boulder Planning & Development Services Energy Code and Green Points Program Changes" http://www.ci.boulder.co.us/buildingservices/codes/lightingord.htm

[27] The IDA estimates that Americans are wasting approximately $1.5 billion dollars in electricity costs per year, through unnecessary upward-focused public lighting. International Dark Sky Association, "An Introduction to the Issues of Light Pollution," http://www.darksky.org/handouts/bc_intro_lp.pdf. If the estimate is accurate, then the cost of the extra electricity works out to about five dollars per resident of the United States and about seven dollars per adult. (Based on the Census Bureau estimate of a U.S. population of 291 million.) The large capital investments involved in changing the light sources are almost always going to be more costly to businesses (and therefore, ultimately more costly to consumers) than the lower electricity bills the IDA predicts citizens will receive as a result of new light fixtures.

[28] The City of Aspen lists preserving the small town character of Aspen as a main reason for passing its restrictive light ordinance. See City of Aspen Code, "Outdoor Lighting," § 26.575.150 http://www.ordlink.com/codes/aspen

[29] See Sky and Telescope Magazine's website for the dates of upcoming meteor showers. http://skyandtelescope.com/observing/objects/meteors/article_588_1.asp

[30] University of Virginia Department of Astronomy. "Leonids 2002". http://www.astro.virginia.edu/Leonids2002/

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