 by Jonathan Talbot

Getting the Best from Your Backyard

Imaging from a suburban backyard can be rewarding, even under light-polluted skies.

As an astrophotographer, I long to image faint targets in the night sky. The problem, though, is that I live under skies awash with skyglow, as many of us do. And while I enjoy taking road trips to dark skies in an effort to image under better conditions, nothing quite beats the convenience and comfort of imaging from my own backyard. Despite being barely able to discern the Milky Way on most clear nights, I've still been able to take many colorful, detailed images of galaxies, nebulae, and star clusters from my suburban home. Here are some of the ways I've found to mitigate the effects of light pollution — common-sense steps that might help you get the most out of your own location.

Shoot High

My backyard in Ocean Springs, Mississippi, is only a few miles from the bright lights of the city of Biloxi along the Gulf Coast. I got interested in astronomy and astrophotography long after setting family roots in the area, so I decided to make the best of what I had.

When I started imaging, I began by setting up my scope in the darkest spot in my backyard, hoping that this simple step would permit me to take good pictures. Unfortunately, my first images displayed ugly color casts, were dim and noisy, and weren't nearly as nice as what I saw others post online. So this was the first lesson I learned to improve my astrophotography: Avoid light domes.

"Light domes" are just that — large glows along the horizon from urban areas that illuminate the sky, often where interesting targets reside. One way to avoid light domes is to simply avoid shooting objects when they are low in the sky. This can mean waiting until your chosen target reaches the meridian (the imaginary line that crosses the zenith from north to south), where it should be best placed to shoot anyway. Some areas of my sky will always be off-limits for imaging, but I can just save the targets in those areas for the times I travel to a star party or other dark-sky site.

As a general rule, I tend to avoid shooting nebulae or galaxies until they get higher than about 40° above the horizon, where the light domes aren't as bad. Some parts of my sky are worse than others, particularly toward Biloxi in the west.

This 40° rule of thumb also helps improve the signal of my images by reducing the effects of *atmospheric extinction*. The lower your target is, the more atmosphere its light must pass through before hitting your sensor, which can be described as airmass = 1 / cos (ZA), where ZA is the zenith angle (angle from zenith to your object). This is an issue because our atmosphere absorbs and scatters light, making targets fainter the closer they are to the horizon. At an elevation of 30° you are looking through twice as much atmosphere than when looking toward the zenith. Additionally, the atmosphere scatters blue light more than it does wavelengths at the red end of the spectrum, meaning that less blue light reaches your scope when your target is low. I take advantage of this by reserving my blue- and green-filtered exposures until my target is highest in the sky, and shoot red exposures when they are nearer to my 40° altitude limit.

GOING DEEP Shooting deep-sky objects from suburban locations is challenging, but the rewards speak for themselves. This deep, colorful image of IC 348 surrounding the bright star Omicron (o) Persei was captured from the author's backyard observatory using a Stellarvue SV70T refractor and a QSI 583wsg CCD camera with color and hydrogen-alpha filters. Unless otherwise noted, all images were taken by the author.

Local Light Pollution

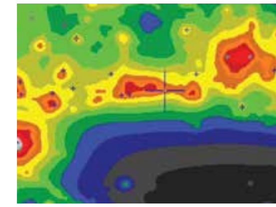
While shooting high in the sky helped improve my pictures, they still suffered from the effects of light pollution. Because of this I needed to understand how *local* light pollution was affecting my deep-sky images. Specifically, just because my scope wasn't aimed directly at a nearby streetlight didn't mean its light wouldn't affect my images. Light tends to find its way into my scope, so I had to find a better way to keep local ambient lights — streetlights, passing cars, and the neighbor's motion-activated security lights — from spoiling my images.

The best solution to local light trespass was to build a permanent home for my telescope — a backyard observatory.

My first observatory was a simple roll-off-roof design. This helped block most stray light from finding its way into my telescope and immediately made a difference in my astrophotography. Light-pollution gradients in my images became less obvious, and I began to see the limits of my other equipment.

Eventually, I decided that my local conditions warranted a more specialized solution to the problem of stray light. So after a decade, I replaced my little roll-off enclosure with an 8-foot dome from Explora-Dome (**explora-dome.com**). A dome only lets in a small section of the sky and thus blocks out anything else. It certainly solved the majority of my neighborhood's security-light problem. But being in a dome takes a little getting used to, because you don't see the entire sky at once.

If you can't build a permanent home for your equipment, there are inexpensive portable observatories that will shield your imaging rig from ambient light. Places to look for one are **365astronomy.com** and Kendrick Astro Instruments (**kendrickastro.com**).



LIGHT POLLUTION MAP: LIGHTPOLLUTIONMAP.INFO

▲ **BRIGHT SKIES** Light pollution surrounding the author's home in Ocean Springs, Mississippi, is relatively severe. This map scales light pollution as most severe in the red zones.

Camera Choice

Once I was getting better data, I noticed how hard it was to get rid of gradients in images taken with a color camera. While today's color cameras are much better than when I started digital imaging almost 20 years ago, a monochrome camera wins out under bright skies, in my opinion. I find it's much easier to remove light-pollution gradients on individual monochrome, color-filtered images — as opposed to those from a one-shot-color camera. I'm able to isolate and remove light-pollution gradients in each color channel before combining them into the final image during post-processing. Additionally, a monochrome camera with a filter wheel allows you to image at full resolution through narrowband filters, which work extremely well to block many sources of light pollution.

That's not to say color cameras don't work. With the addition of a clip-in light-pollution filter, DSLR cameras can take nice deep-sky images under urban skies. These filters are available from Astronomik Filters (**astronomik.com**) and other retailers for either APS or full-frame DSLR cameras. They work very well at increasing contrast and suppressing the glow from typical high-pressure sodium lights, though the ongoing, widespread switch to LED lighting might reduce the effectiveness of these filters in the future.

▲ **SHIELD YOUR SCOPE** Blocking stray light is an important step to improving your suburban imaging. The author went through a series of methods to block local light trespass from ruining his images, eventually settling on an ExploraDome observatory.

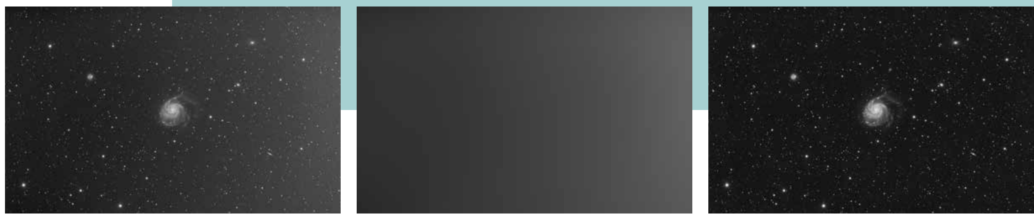
Narrowband filters are also available in clip-in format for DSLR cameras, but keep in mind that any of these has a one-shot color sensor, so you won't be imaging at full-resolution through a narrowband filter, and here's why. The camera's sensor uses a *Bayer filter matrix* that divides the pixels into three groups: 50% have a green filter over them, while 25% each are filtered for red and blue wavelengths, respectively. So to create a color image, each color channel must fill in the missing space between the pixels of each color (by interpolating the values nearby on the sensor), so your image will not be as high resolution as those taken with a monochrome camera with multiple exposures through single-color filters.

If you do use a DSLR or other one-shot-color camera to image under light-polluted skies, consider limiting your target choices to areas close to the zenith where gradients will be less severe. Find what works best for you and your equipment.

Shoot Lots of Images

Another way I improved my backyard imaging before processing my images was simply to shoot a lot of exposures. Sure, I can record my target in, say, a 3-minute exposure, but with very few exceptions it's a pretty noisy image. Our biggest goal in astrophotography is to achieve a good signal-to-noise ratio in our images, in order to bring our target out from the background sky. And under a pall of light pollution, that sky background accounts for a lot of unwanted signal, so we need lots of exposure to bring out our target. Additionally, removing light-pollution gradients from my images reduces the overall signal, so the more time I can dedicate to image-acquisition, the better my images will turn out.

I generally try to record at least 4 hours of exposure through each filter, and more when imaging through narrowband filters. I often dedicate 15 hours or more of exposure time to a single target to ensure I have adequate signal to work with. If you're imaging with a one-shot-color camera or DSLR, I suggest at least 4 hours of total exposure time, even for bright targets. The more time you invest, the better your images will be.



▲ **TACKLING GRADIENTS** *Left:* Light pollution reveals itself in this image of spiral galaxy M101 (above) as an uneven background, often appearing dark on one side of an image and bright on the opposite side. *Middle:* The gradient was isolated using the DBE tool in *PixInsight*. *Right:* Once removed from each color-filtered image, the results can then be stretched to reveal faint details, as seen on the facing page.

Individual exposures might be short, but taking many of them and stacking them together averages out sources of noise in the final while increasing the target's signal.

Speaking of individual sub-exposures, what is the optimal exposure time? That will depend on several factors, depending upon your particular camera, optics, and local light pollution. Find an online exposure calculator (like this one: **https://is.gd/DgrFMn**) to help you figure this out, though a good rule of thumb is to avoid saturating your detector.

One thing that can help me determine my exposure goal is by measuring the brightness of the sky in my backyard. A handy tool to do this is a Sky Quality Meter from Unihedron (**unihedron.com**). These devices provide unbiased reading of the sky brightness in magnitudes per square arcsecond (MPSAS). For example, a typical, suburban night sky is about 19 to 20 MPSAS if there's no bright moonlight. For context, a pristine sky with no light pollution yields a value of 22, whereas an inner-city sky is often below 17. Knowing my sky's value helped me determine how much exposure I need for a given target. A 1-magnitude decrease in the meter's value, say from 18 to 17, means the sky brightness is 2½ times brighter. So it takes 2½ times more exposure time to get the same SNR, assuming everything else is equal.

Eliminating Gradients

Finally, once I improved my raw-image quality as much as I could, the final step in the battle against light pollution was to remove skyglow gradients from my images during post-processing. Even imaging under a dark sky produces subtle gradients that need addressing, so this step is essential no matter where I shoot.

Gradient removal is done on each stacked result but before combining into a final color image. This is perhaps the most important step to ensure a good astrophoto, because images with strong gradients are impossible to color balance. How you perform this step depends on the image-processing software you use. Most of these programs include tools to deal with gradients. I prefer the Dynamic Background Extraction (DBE) tool in *PixInsight* (**pixinsight.com**), and a helpful tutorial on using this powerful tool can be found on page 68 of this magazine's September 2014 issue.

▲ **COLORFUL RESULT** Once you address gradients in each color-filtered image stack, you can then combine the results into a dazzling result virtually indistinguishable from a shot captured at a dark-sky location.

If you're shooting with a one-shot-color camera, stack your images first. Then split the result into its red, green, and blue individual color channels; remove the gradients in each; and then recombine and color balance the result. After that, the processing steps are no different than for images taken under pristine skies.

These important steps each have greatly improved the quality of my images, even from the murky glow of city lights. And it's hard to beat the convenience of shooting from home, which can open up many nights that you otherwise might have stayed indoors.

■ JONATHAN TALBOT, a retired flight meteorologist for the U.S. Air Force Reserve, spends all his free time these days imaging the night skies.

◀◀◀ **SHOOT THE ZENITH** One tried-and-true technique for mitigating the effects of light pollution in astrophotos is to target objects that pass very high in your local sky. This deep image of M33 was recorded over several nights as the galaxy passed near the zenith.

◀◀ **PUSHING THE ENVELOPE** Imaging relatively faint targets, such as the colorful object NGC 2170 in Orion seen here, is difficult but possible from urban locations. The author recorded each sub-exposure as the nebula crossed the meridian over the course of many nights.

◀ **LOTS OF SPACE** Light pollution is often easier to address in an image when the target does not fill the entire frame. This shot of M63 had strong gradients in each color channel that the author easily addressed in *PixInsight* before combining them into the color result seen here.