



High Dynamic Range
for Everyone

The Complete Photographer

Guy Huntley

A TUTORIAL ON HDRI PHOTOGRAPHY

Presented by:

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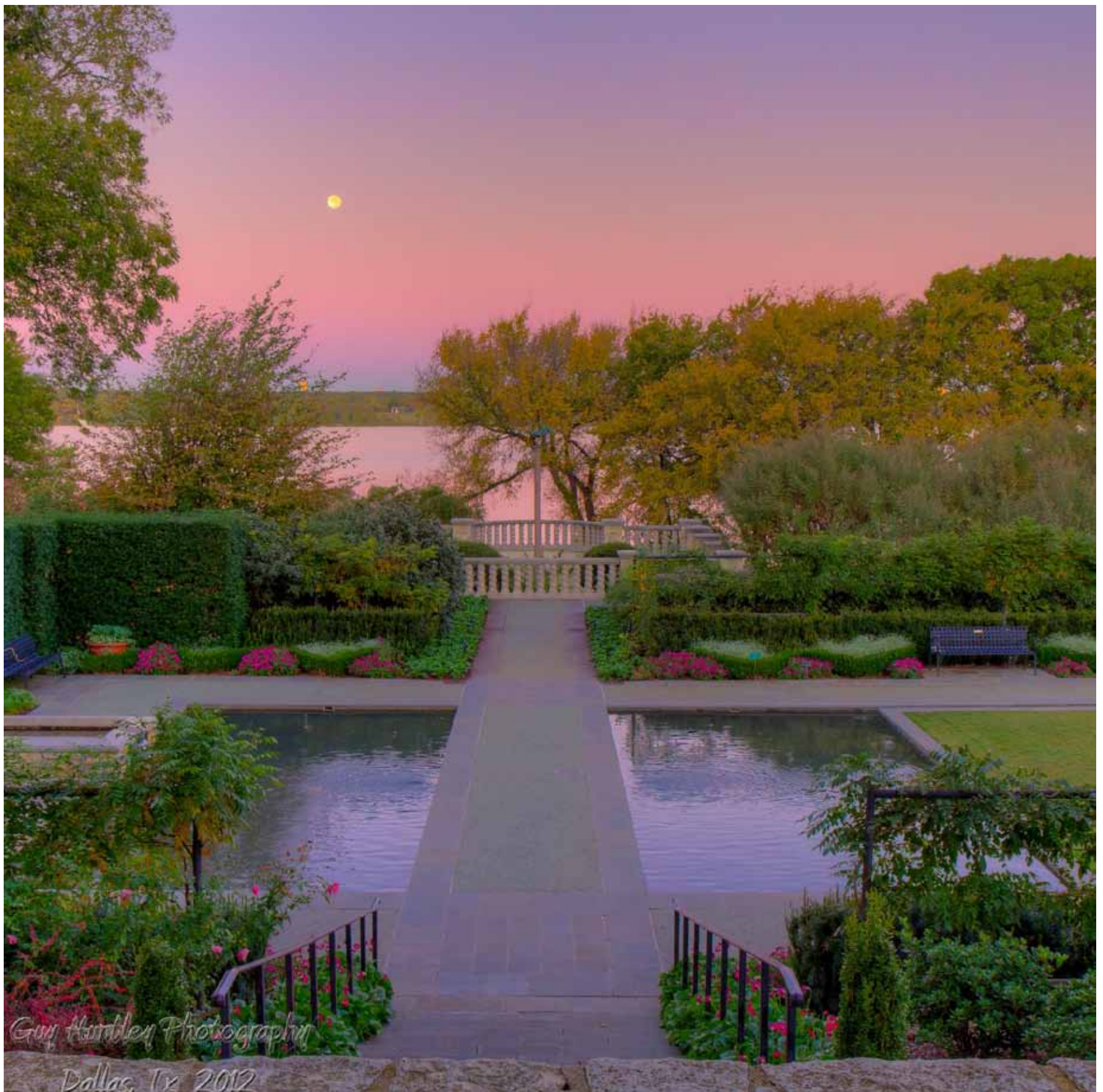
INTRODUCTION

High Dynamic Range Imaging or HDRI Photography is hot. Since around 2008 HDRI has emerged from a small niche to a main stream technique embraced by nearly all software and hardware vendors. In 2008 [Photomatix from HDRSoft](#) had the market pretty much to itself. Since that time an astonishing number of new and existing software vendors have leaped into the HDR fray. HDR Labs has listed most if not all of the players [here](#).

Hardware vendors are also increasing support for HDR imaging. Most DSLRs have supported exposure bracketing from the beginning. But the feature was provided primarily as a convenience for those not wanting to take a chance on a bad exposure. HDRI techniques were used in the research and motion picture industry since around 2000. However it was the release of affordable consumer grade image merging and tone mapping software in the 2008 time frame when HDRI started taking off. Now we are seeing cameras with HDR processing and tone mapping built into the camera itself. The hardware and software support will only get better.

Current HDR processes are constrained by the 14 bit limit of current sensor technology. Below we will explore why HDRI photography is becoming increasingly popular, what the limitations and work v are, and how to expose the images. There are numerous books, websites, and tutorials on how to take and process the images so that only be touched on here. We will explore the what and why of the technology. We will also look at exposure techniques to get the right bracketing sequence which was a real challenge.

Links to resources are provided at the end.



WHY HIGH DYNAMIC RANGE IMAGING

In August, 2008 I had been planning to try HDR for number of months. I take pictures for club events. One of the events was at the Metro Grill on the West side of Central Expressway in Dallas. It was 6:30 PM on a hot August evening. The picture below was the first shot. It was



the worst light possible. With a back lit building there was no way I could make this picture look good without a lot of work. I was not going to return at 7:00 AM for the "Golden Hour".

Then I remembered what I had read about HDR. All I needed to do was switch the camera to rapid fire and automatic exposure bracketing.



What could be simpler?

I did not have a tripod. So I stood as steady as possible and bracketed the three exposures above.

I quickly purchased an early version of Photomatix. The first image to the right had promise.

So I tone mapped the 32 bit exr file. Several more times with different settings to create the images below:

The last "grunge" image seemed to fit the art deco atmosphere of the grill so that was the one published. With HDRI we can take beautiful pictures at high noon! There is no "bad light!"



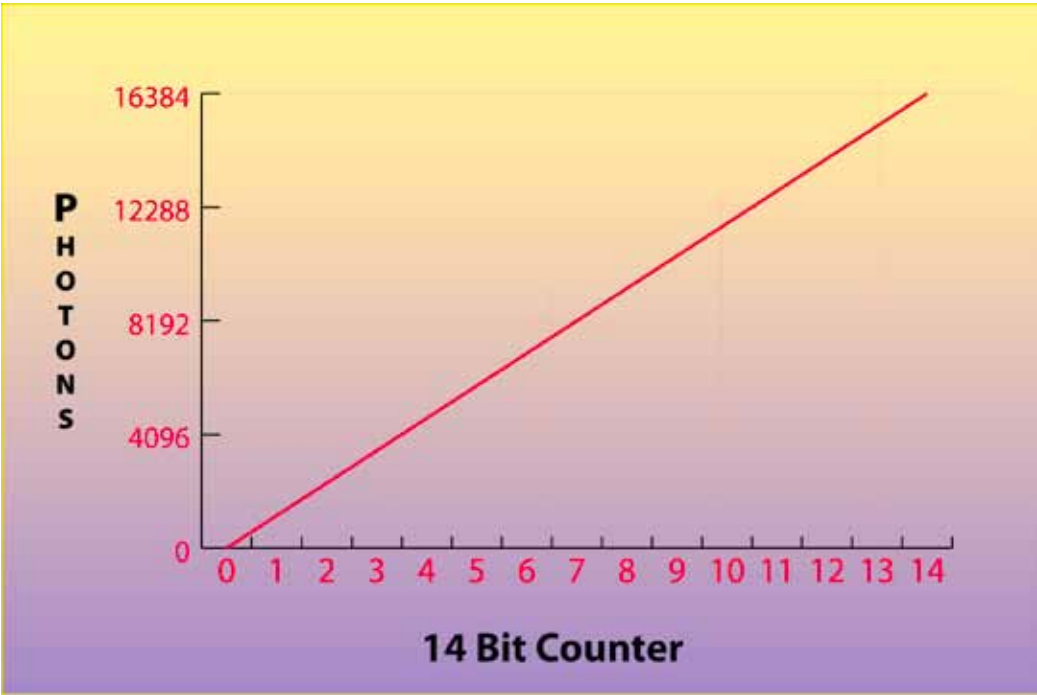


THE PROBLEM

So what is the problem that HDR processing is trying to solve. The problem is that our existing sensor technology, along with film, print, displays, and all of our other image display technology has a relatively small range of light values compared to what we see in the world. Present 14 bit sensor technology can capture only 12 stops or EV of light. But frequently we need to capture scenes with 18 to 21 or more “EV”.

We hear a lot about Exposure Values, or EV. Wikipedia has a good article on [Exposure Value](#). Basically, a change of +1 EV or + 1 stop doubles the light. Examples are provided below. Most frequently EV is used as a ratio. But if the EV is referenced to a particular ISO, generally ISO 100, then it references the amount of light power or illuminance of the exposure. For our purposes we deal with EV as just a ratio.

The active element of our sensors are a 14 bit counter. Each pixel has a red channel, a blue channel, and two green channels. With a ten megabit sensor there are forty-million 14 bit counters. That is a lot of processing power going on just in our sensors. Our sensors are every bit as complex as a microprocessor!



So each one of these counters count up to 16,383 very fast. When the count gets to 16,394 the dreaded blinkies appear. That is the overflow bit.

This counting scheme makes perfect sense to the computer. The computer counts linearly where the next photon is just as important as the last photon.

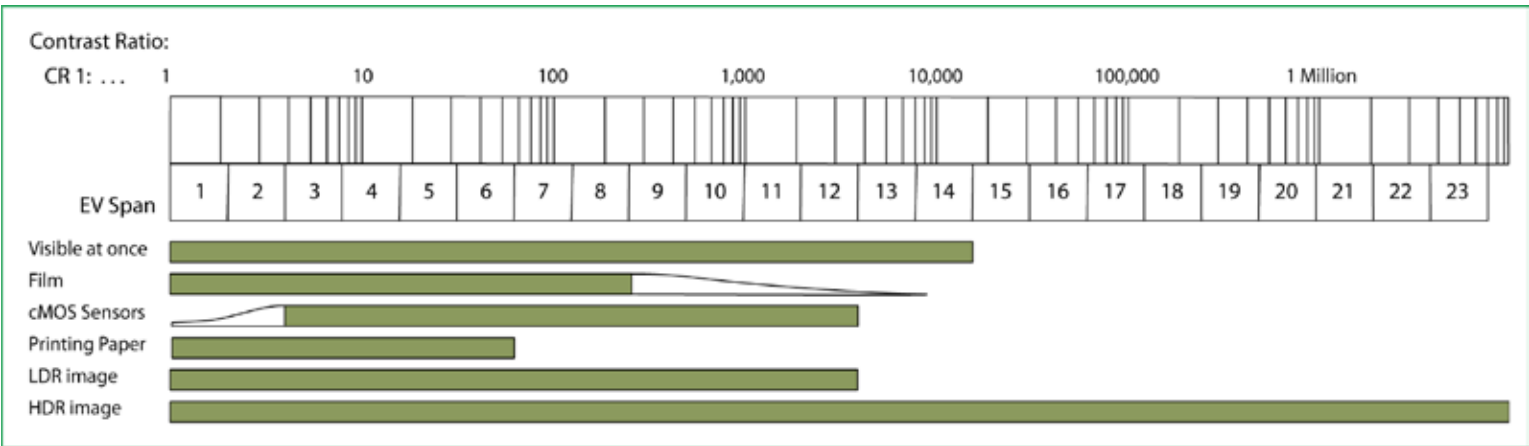
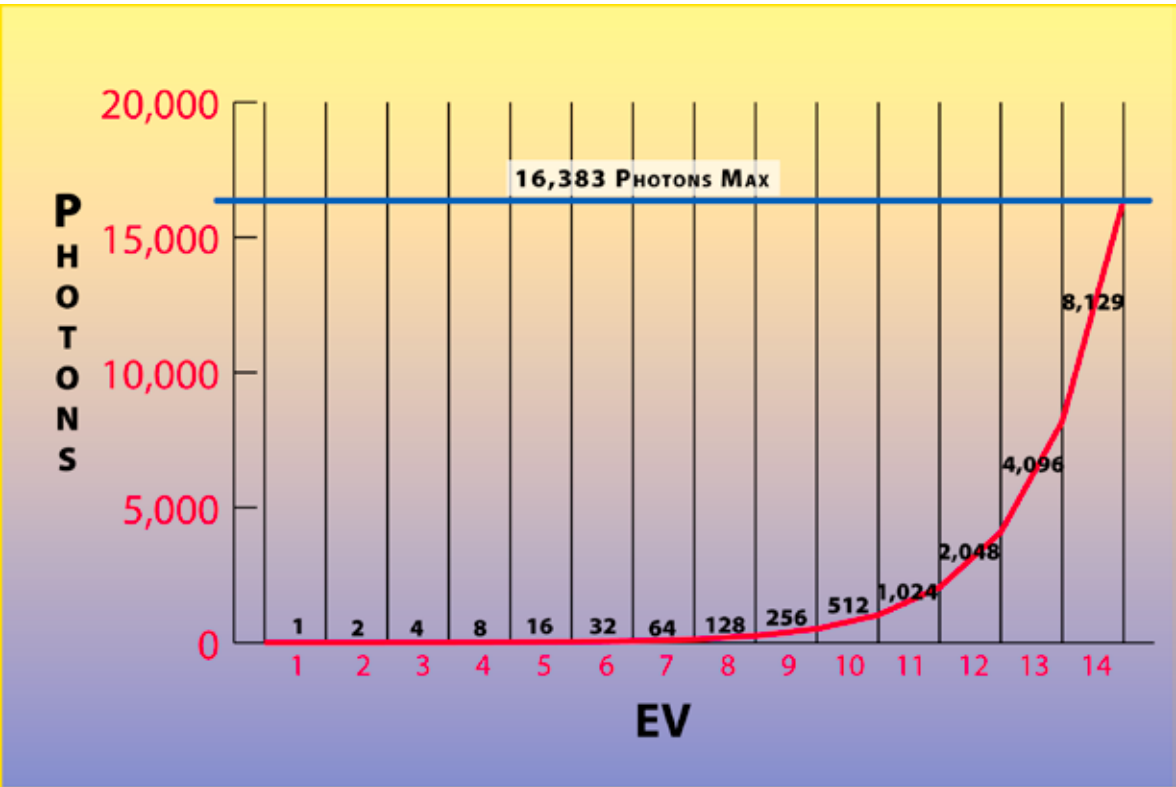
But that is not the way we see the world. We perceive the world logarithmically where doubling the number of photons is significant. If I have one dollar and I find a new dollar, that is important. If I have a million dollars — a new dollar is not so important.

We perceive light as a log scale to the below. We frequently hear the mantra: “expose to the right”. If we have a scene in the bottom 4 to 6 EV of our exposure range then we are better off by over exposing the image to the upper 8 to 10 EV. Far more information is cap-

tured by “exposing to the right”. We keep all the detail. Later we can reduce the exposure in post processing.

The Contrast Ratio table below graphically illustrates the EV spans of various media. Our eyes are capable of seeing up to 14 EV and with accommodation up to 21 EV. Film had good fidelity up to about 10 EV with decreasing fidelity out to 14 EV. Our electronic sensors are capable of 12 EV. Printing paper is capable of 6 to 7 EV.

Which brings us to an interesting point. We have been practicing “tone mapping” whenever we have been committing our images to print. The “Highlight and Shadows” adjustments are simply mapping those tonalities that are out of range of our display devices - our monitors and print media - to within our displayable range. We are “compressing” the 12 EV images down to the 7 to 9 EV we can display. What we are doing with HDR



Stage	Dynamic Range	Stops
Typical outdoor, sunlit scene	100,000:1 or more	~17 EV
Human Eye	10,000:1	~14 EV
Film Camera	up to ~2,000:1	~11 EV
Digital Camera	typically ~ 4,000:1	~12 EV
Good Computer Monitor	500:1 to 1,000:1	9 - 10 EV
Typical Photo Print	100:1 up to 250:1	7 - 8 EV

techniques is pushing our limited sensors to match the real world scenes. We want to compress the 18 to 21 EV we see in the real world down to the 6 to 7 EV available on our print media.

Above is another table illustrating typical dynamic ranges of various media:

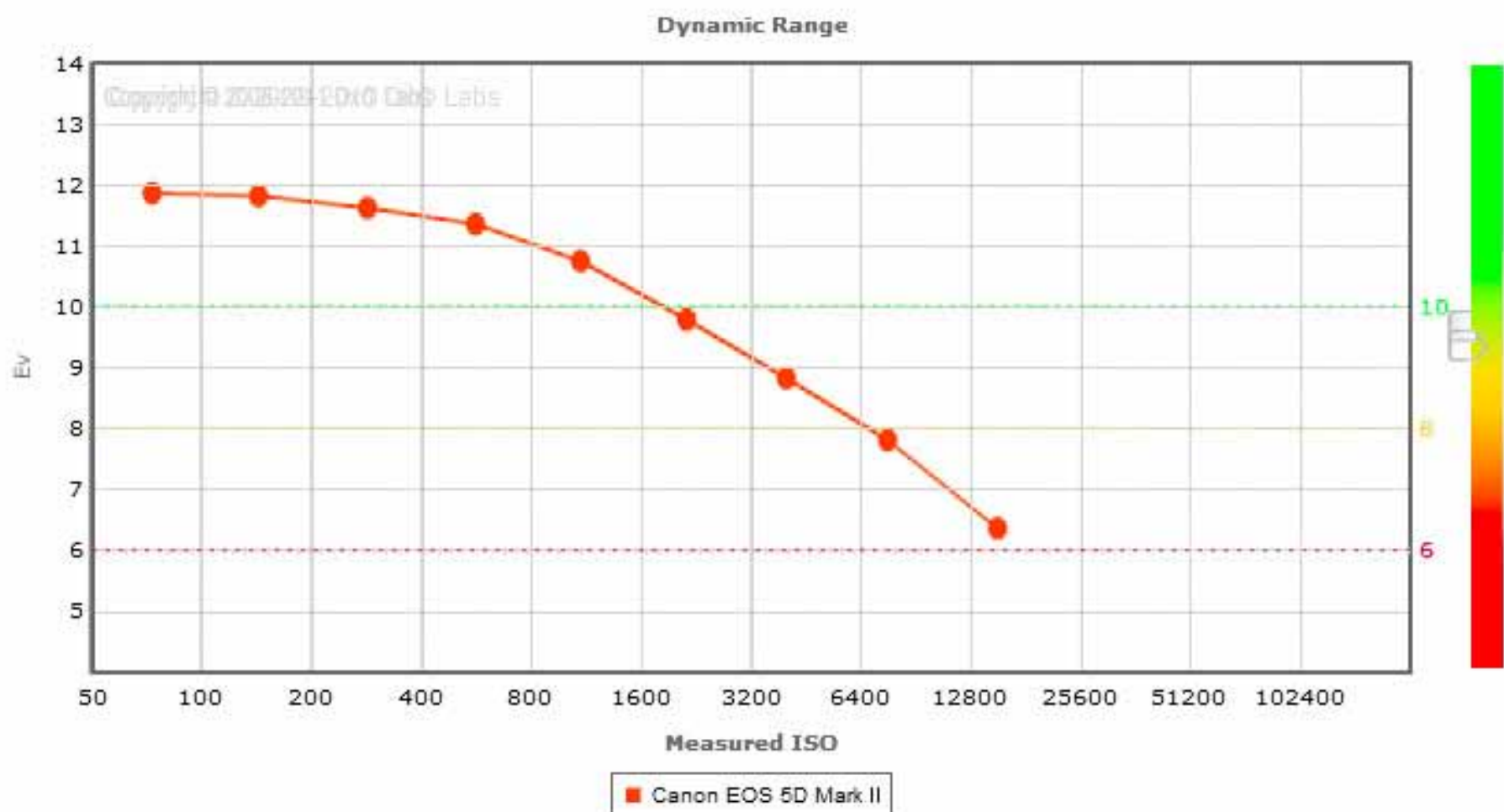
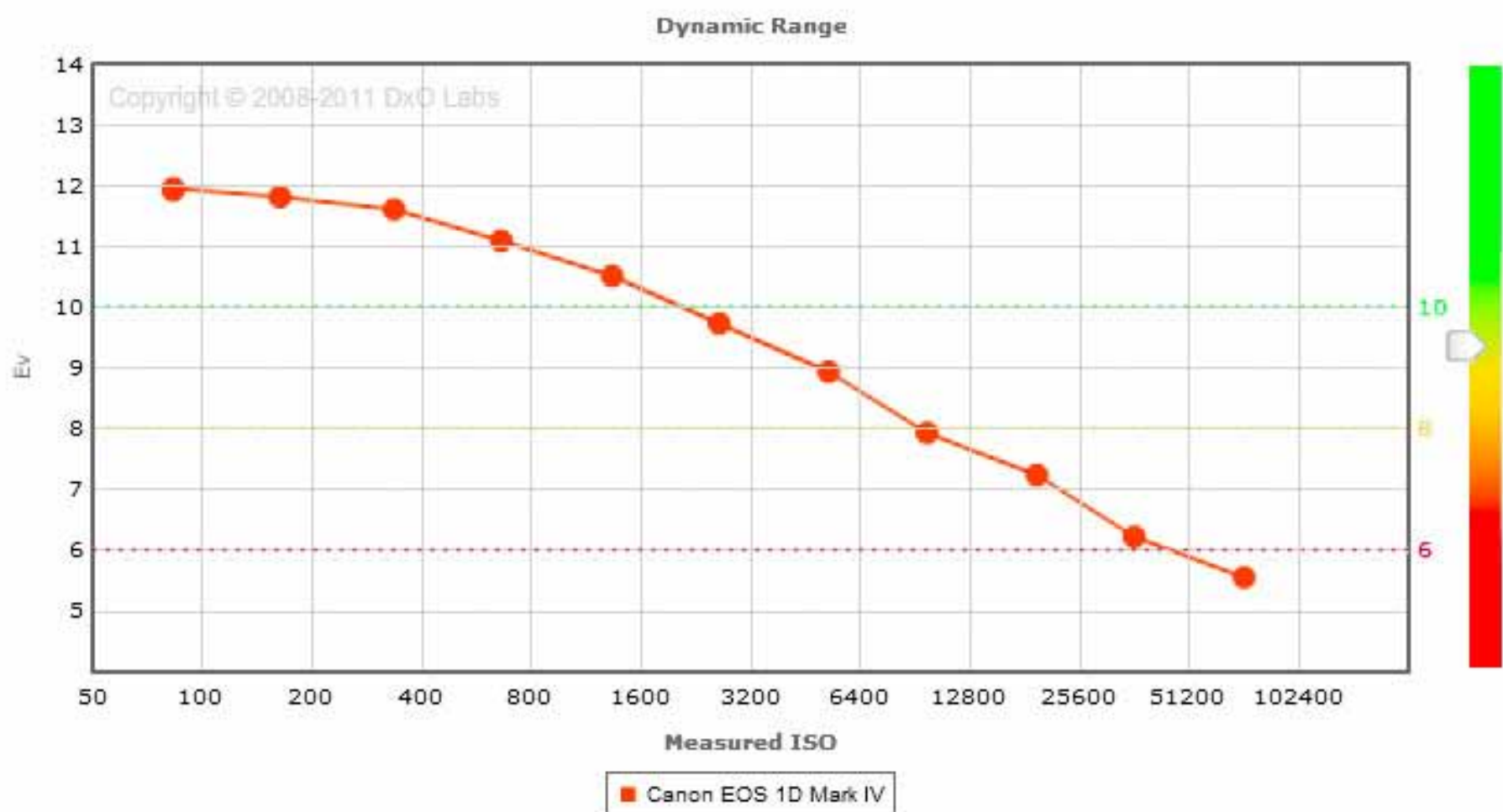
The table to the right is one of the rare cases where EV actually refers to light luminosity or power. In this case EV is referenced to ISO 100. The bracketed area are the areas we typically photograph.

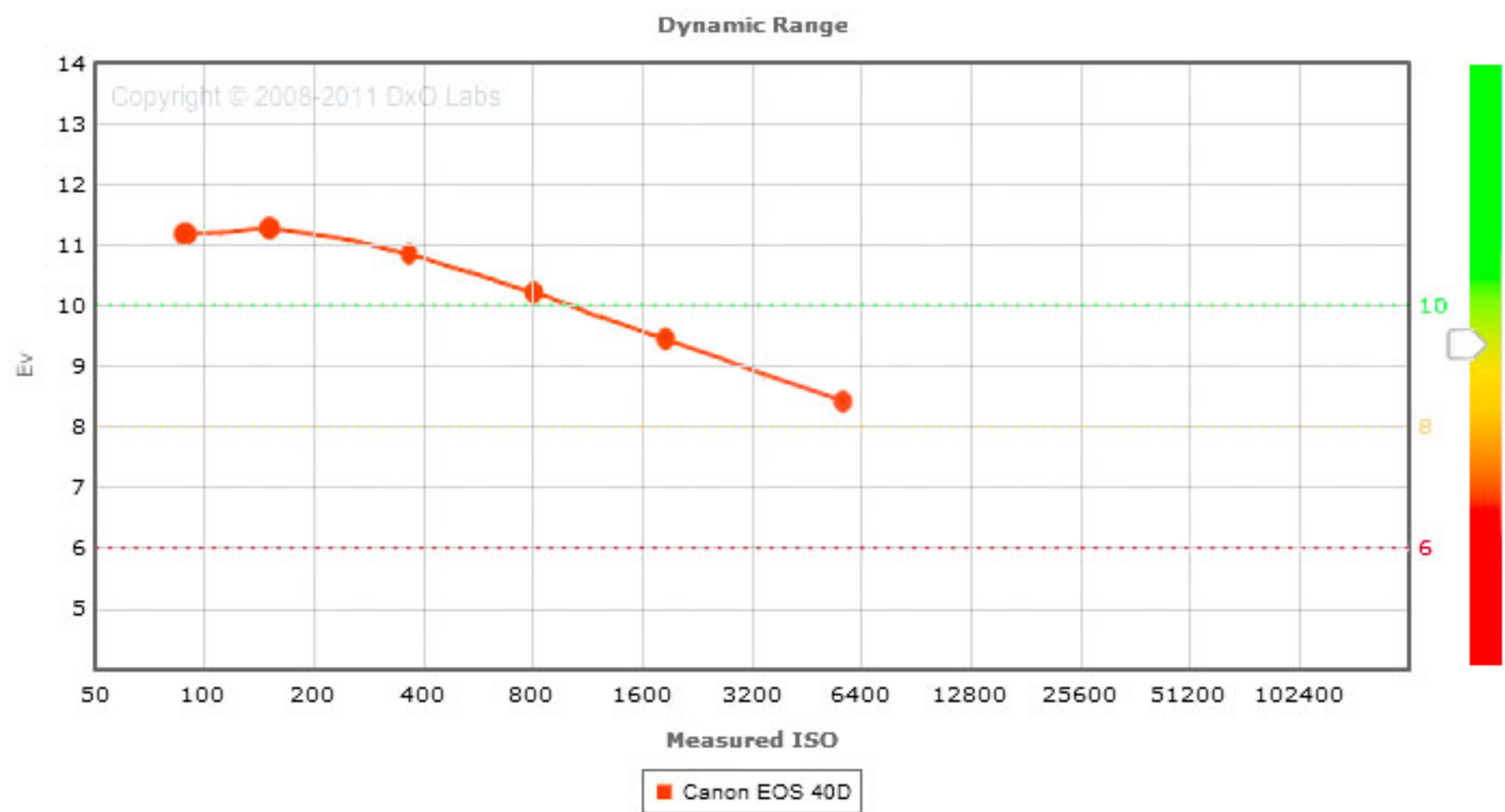
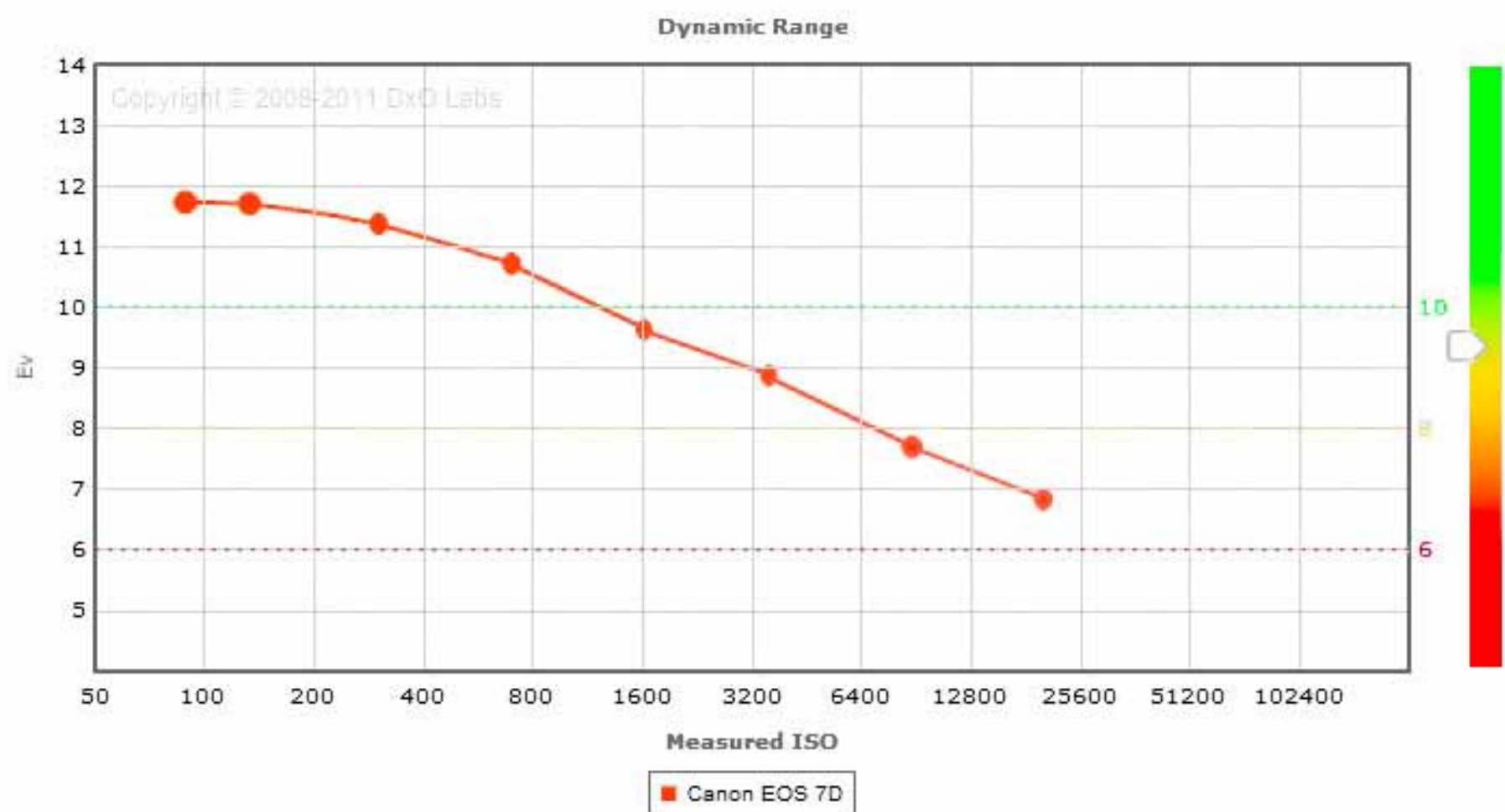
In the Christmas light scene discussed below there were 14 exposures taken 1 EV apart for a total of a 26 EV light span. (15 + the 12 EV sensor span at ISO 100) On the chart to the right the images went from an EVO_{100} 21 (the Christmas lights) to about a -5.

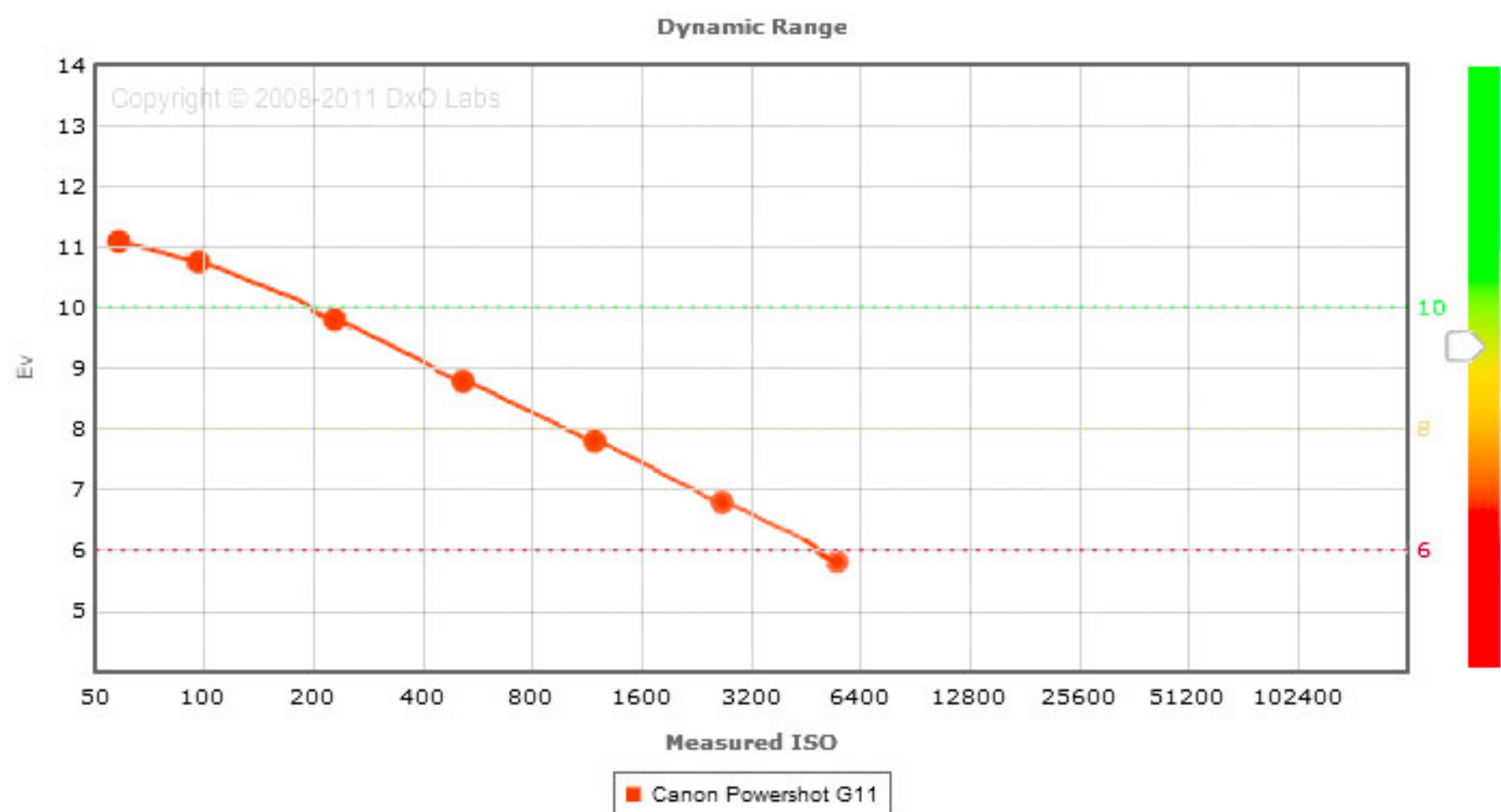
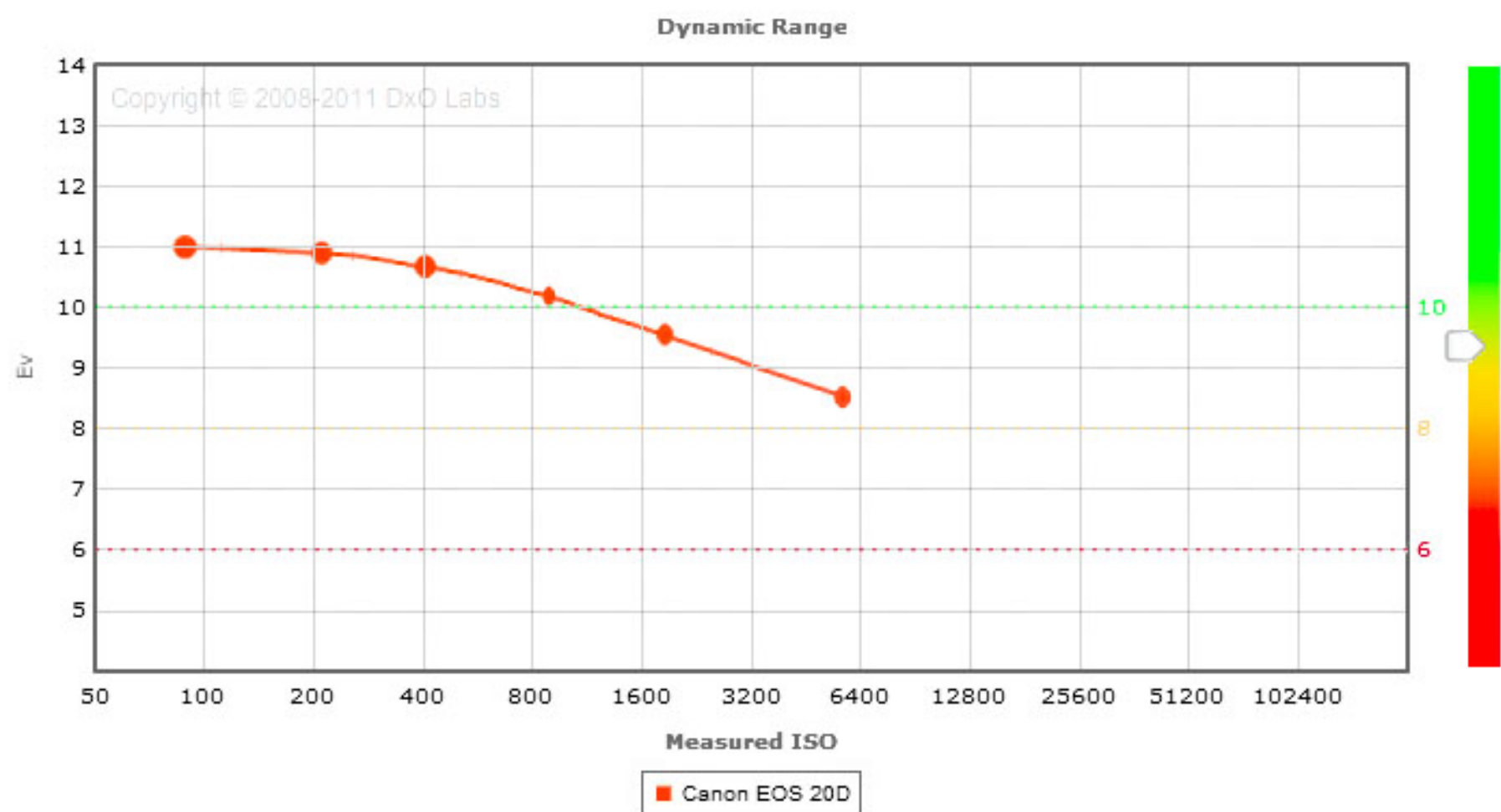
EVO_{100} TYPE OF LIGHTING SITUATION

- 6 Night, away from city lights, subject under starlight only.
- 5 Night, away from city lights, subject under crescent moon.
- 4 Night, away from city lights, subject under half moon. Meteors (during showers, with time exposure).
- 3 Night, away from city lights, subject under full moon.
- 2 Night, away from city lights, snowscape under full moon.
- 1 Subjects lit by dim ambient artificial light.
- 0 Subjects lit by dim ambient artificial light.
- 1 Distant view of lighted skyline.
- 2 Lightning (with time exposure). Total eclipse of moon.
- 3 Fireworks (with time exposure).
- 4 Candle lit close-ups. Christmas lights, floodlit buildings, fountains, and monuments. Subjects under bright street lamps.
- 5 Night home interiors, average light. School or church auditoriums. Subjects lit by campfires or bonfires.
- 6 Brightly lit home interiors at night. Fairs, amusement parks.
- 7 Bottom of rainforest canopy. Brightly lighted nighttime streets. Indoor sports. Stage shows, circuses.
- 8 Las Vegas or Times Square at night. Store windows. Campfires, bonfires, burning buildings. Ice shows, football, baseball etc. at night. Interiors with bright florescent lights.
- 9 Landscapes, city skylines 10 minutes after sunset. Neon lights, spot-lighted subjects.
- 10 Landscapes and skylines immediately after sunset. Crescent moon (long lens).
- 11 Sunsets. Subjects in deep shade.
- 12 Half moon (long lens). Subject in open shade or heavy overcast.
- 13 Gibbous moon (long lens). Subjects in cloudy-bright light (no shadows).
- 14 Full moon (long lens). Subjects in weak, hazy sun.
- 15 Subjects in bright or hazy sun (Sunny f/16 rule).
- 16 Subjects in bright daylight on sand or snow.
- 17 Rarely encountered in nature. Some man made lighting.
- 18 Rarely encountered in nature. Some man made lighting.
- 19 Rarely encountered in nature. Some man made lighting.
- 20 Rarely encountered in nature. Some man made lighting.
- 21 Rarely encountered in nature. Some man made lighting.
- 22 Extremely bright. Rarely encountered in nature.
- 23 Extremely bright. Rarely encountered in nature.

One mystery is how the camera sensor performs with varying ISO settings. [DXO Labs](#) provides software for processing and refining images. As a service to the photographic community they provide an on-line database through [DXO Mark](#) of all the camera and lens combinations supported by their software. It is a terrific reference. Below are six cameras of various types and vintages. What is important is the EV vs ISO performance.

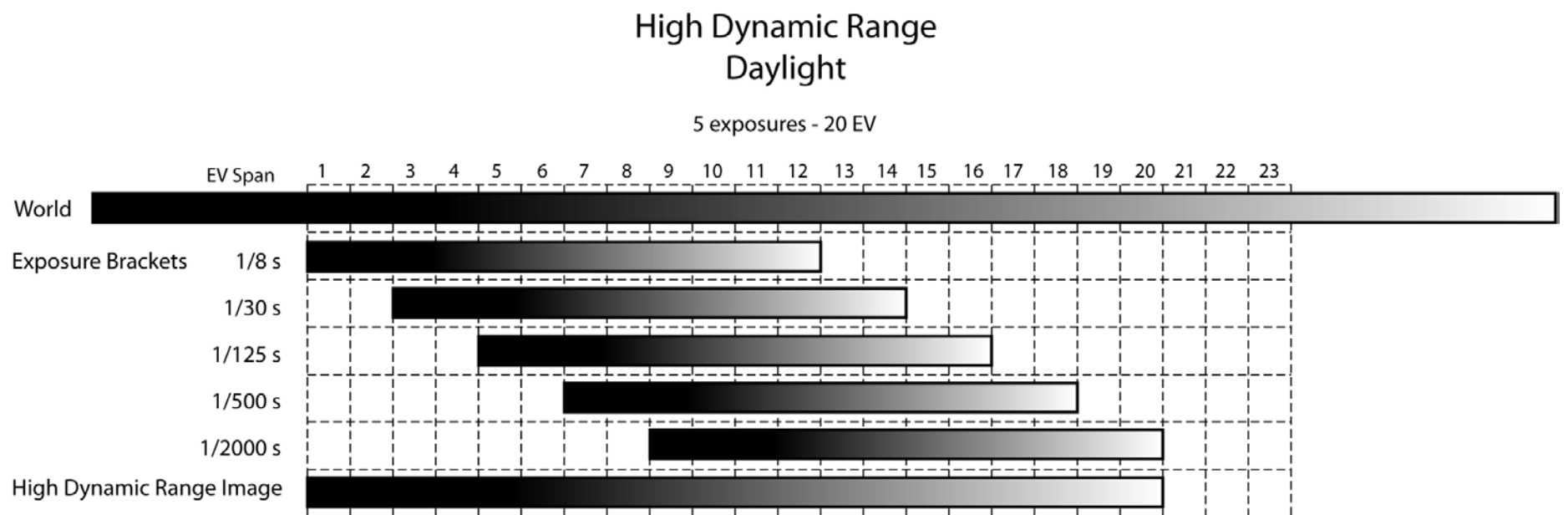
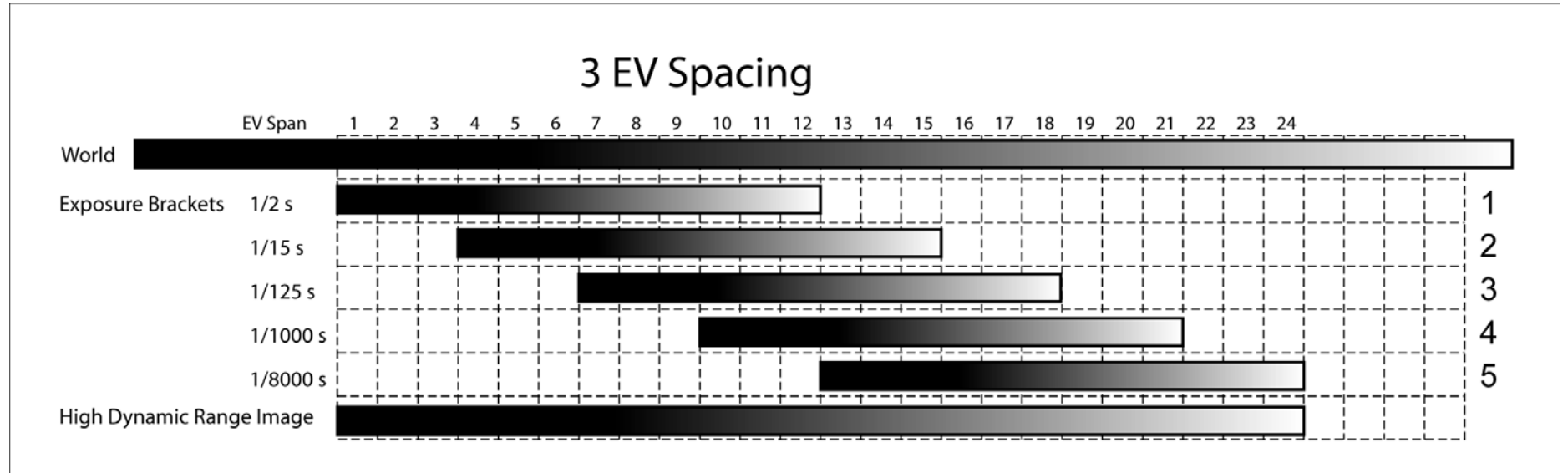
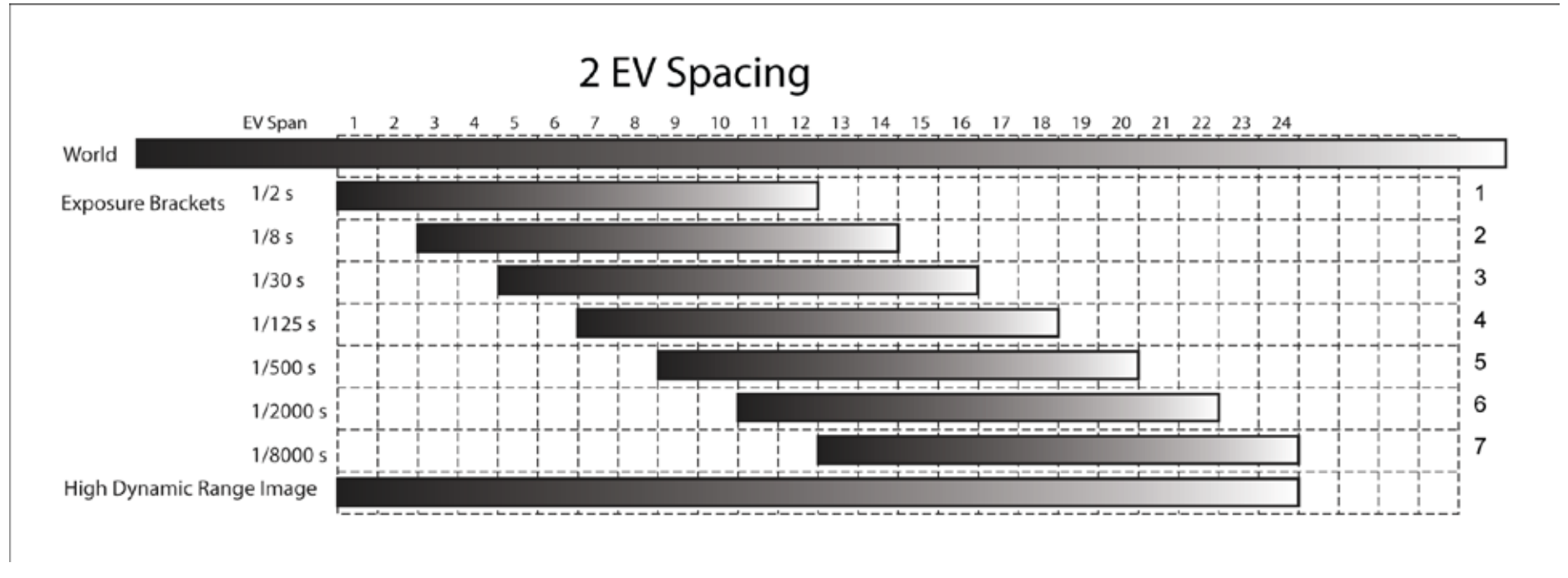






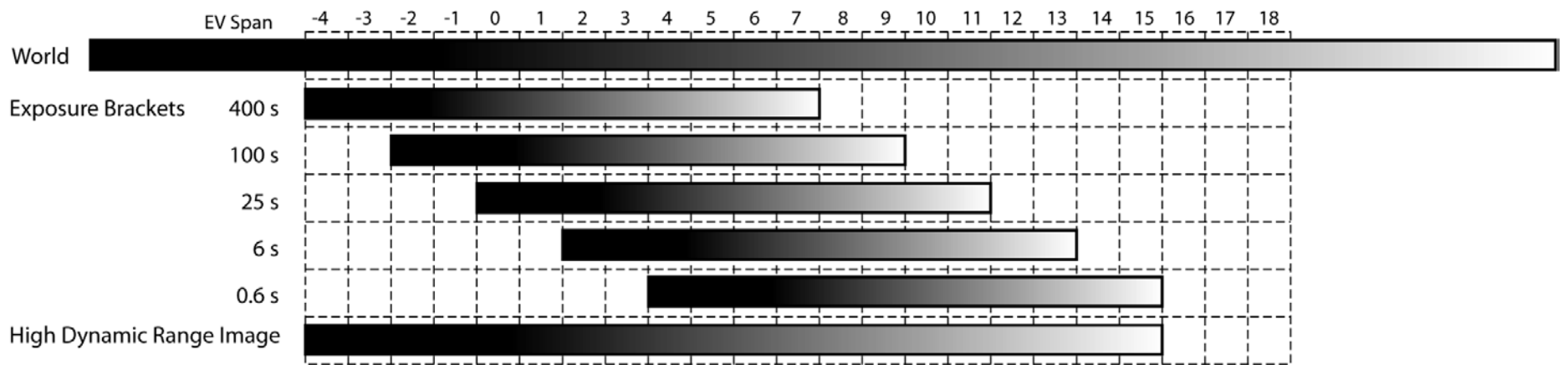
What is instructive is using HDR bracketing the ISO can be pushed quite high. The noise reduction capabilities of Lightroom, DXO Optics Pro or others can be used effectively. The most important observation is we will not see any sensor EV range improvement with existing technology.

The two slides below are an offshoot of the Christmas light decoration photos discussed below. A few years ago I wanted to capture and print all the light in the front yard. It took 13 exposures in at 1 EV intervals. The question was asked what would happen with 2 and 3 EV exposures. The answer was there was no discernable difference with 2 EV exposures but the bricks started blocking out at three EV exposure. That was with Photomatix. I did not try other software packages. And this was with a dark scene with long exposures. A 3 EV setting works fine on daylight scenes.



High Dynamic Range Night

5 exposures - 20 EV



However, these were night images with long exposures. All the recent cameras now support up to 3 EV exposure spacing. The following two charts show the same 20 EV spread during daylight and night.

The question frequently asked is: “Can’t I do the same thing with just one image?” The answer is yes, one image can be tone mapped to bring out all the available detail. This is an effective technique. However, it is not possible for only one image to bring out all the highlight and shadow detail available in the original scene. Details beyond pure white cannot be recovered. Details below pure black cannot be recovered. Information simply cannot be restored that was never recorded.

Always use mirror lockup when taking images between 1/30 to 1/2 of a second to minimize mirror slap vibration artifacts.

HOW TO TAKE THE PICTURE

Should the sequence be hand held or on a tripod? Most of the published advice is to always use a tripod. In the early days the auto alignment capabilities of stacking software was not very accurate. Consequently using a tripod was a necessity. Modern stacking software in Photoshop, Photomatix, Nik HDR Efex Pro and others is, if not perfect, close enough. The software automatically aligns and crops the stack.

By far the majority of my HDR sequences are taken hand held.

Checklist for taking hand held sequences:

1. Set the white balance to anything other than auto. It is not likely that the white balance will change between exposures but why take a chance
2. Set the ISO as low as possible but high enough that the longest shutter speed is greater than 1/60 second.
3. Set the drive mode to continuous or automatic shooting
4. Set the camera on Manual Mode with the desired aperture.
5. Focus then set the lens to Manual. This will prevent the lens from refocusing between shots.
6. Set the metering mode to spot metering.
7. Set the Auto Exposure Bracketing (AEB) range by spot metering the most significant highlight and shadow details in the scene.
8. Stand firm and pull the trigger.

Checklist for taking tripod mounted sequences is the same as above with the exception

1. The ISO can be set down to 100.
2. As many exposures as required can be taken by manually setting the shutter speed.
3. Use mirror lockup if any of the exposures fall in the 1/30 to 1/2 second range.

CHRISTMAS LIGHT DECORATION EXAMPLE

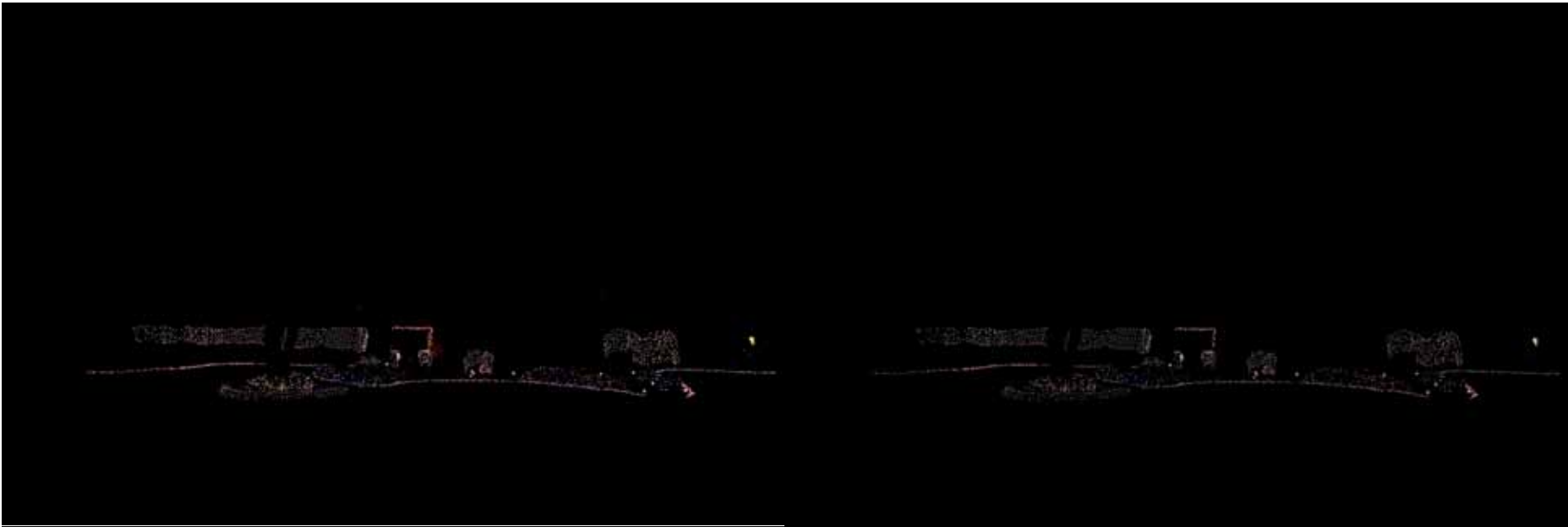
As discussed above, For several years I tried to take effective pictures of the Christmas light decorations. None of the masking exercises tried in earlier years were effective. The new found HDR techniques worked out quite well.



A sequence of 14 images were taken at ISO 100, F/8.0 and a shutter speed in 1 EV steps from 8 minutes to 1/15 seconds is shown below.

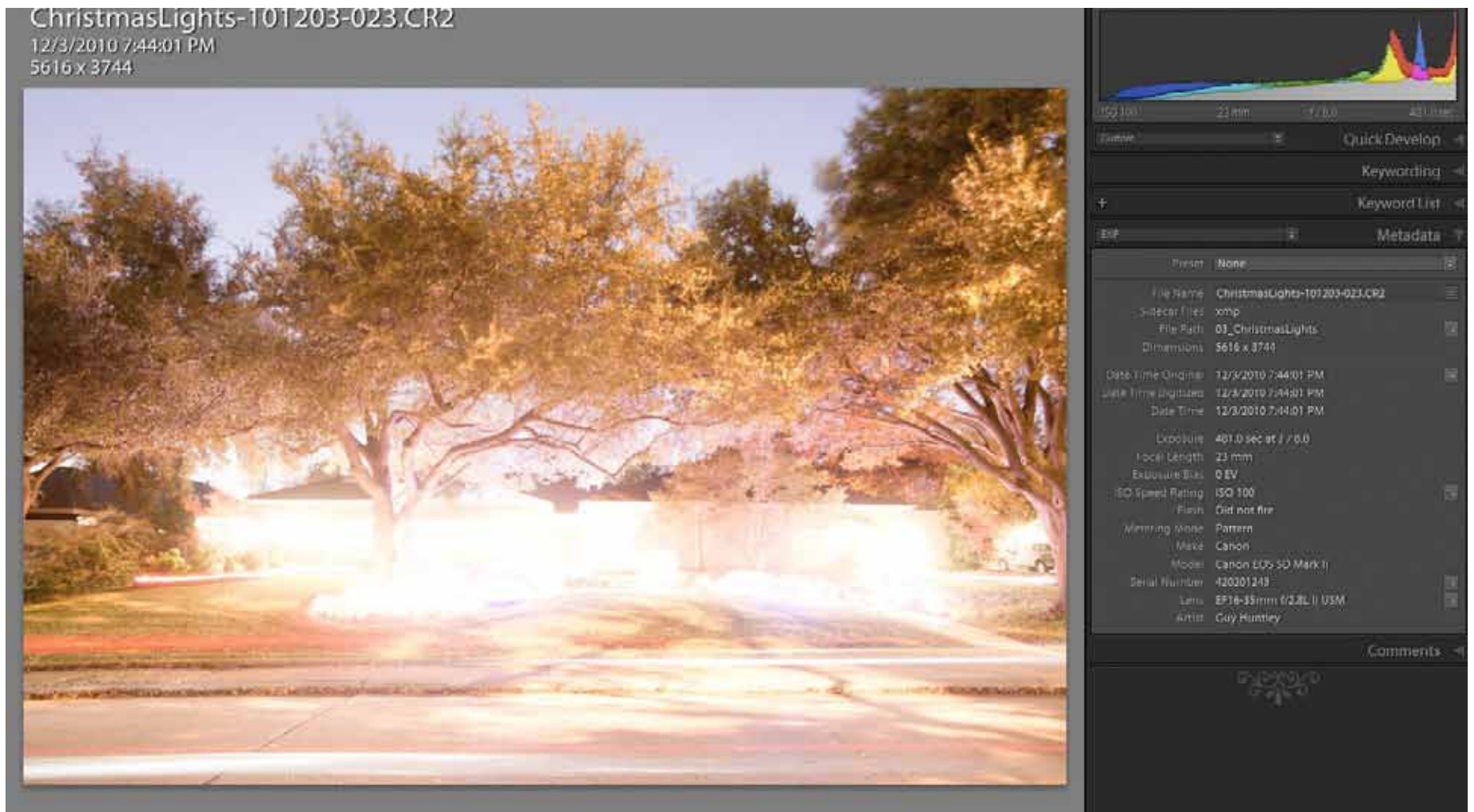




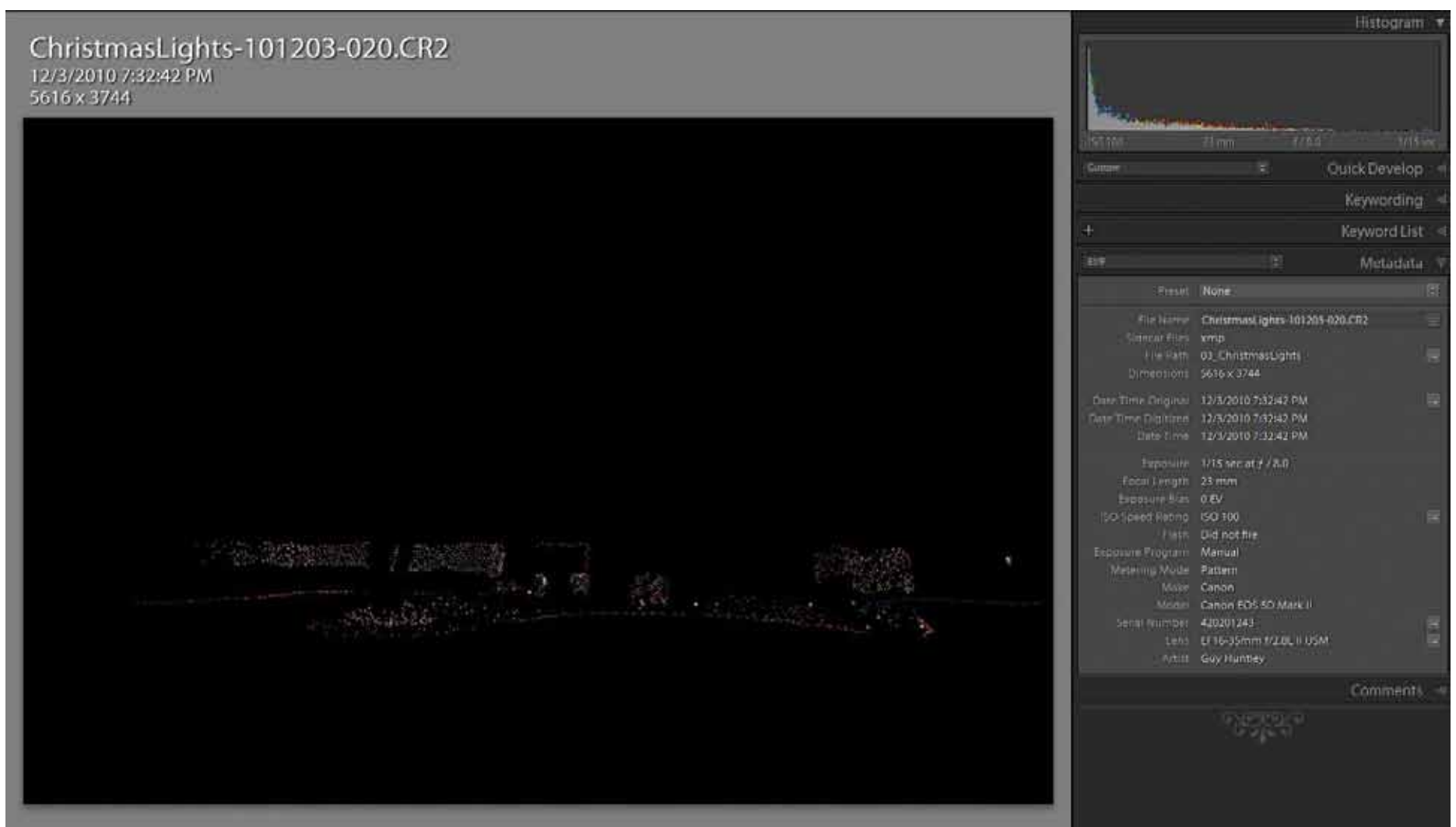


WHAT ARE WE LOOKING FOR IN AN EXPOSURE BRACKET

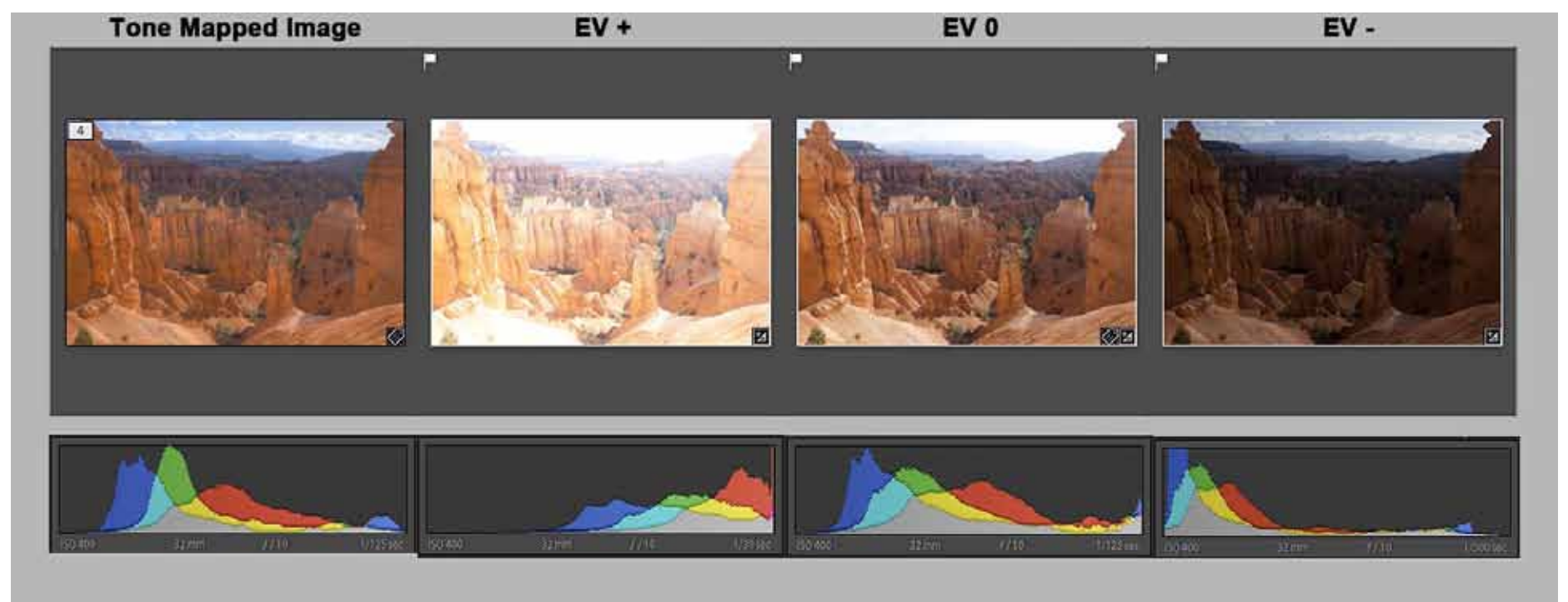
In the brightest, longest exposure we should see all of the shadow detail. The RGB Histogram is key. There should be detail from the far right (all the blocked highlights) to the far left. The histogram should reach but NOT touch the left edge.



In the darkest, shortest exposure we should see all of the significant highlight detail. The sun and specular reflections are not significant and must be ignored. The detail should spread from the far left (where the shadows are blocked) to the far right. With the exception of the sun and specular reflections, the histogram should reach but NOT touch the far right edge.



Below is another set of images taken at Bryce Canyon. This is one of my earlier pictures. Notice that the EV + histogram does not extend all the way to the left. What I should have done is narrowed the EV spacing and reshot. Below is a procedure to avoid this in the future. This



sequence worked out because there is significant detail in the mid range. However, **any images where the histogram is bunched on the left or the right with no significant detail in the mid range should be discarded.** Poorly exposed images confuse tone mapping software and ruin the final image.

FILE TYPES

We are familiar with the myriad 8 bit and 16 bit file types. With HDRI we are moving into a brand new world of 32 bit files. The 32 bit files are significantly different from the earlier files. The differences are explained at length in Christian Bloch's [HDRI Handbook](#) and will not be discussed further. The significant question is should they be saved and if so what format. The table below shows the various formats:

	TGA* (8 bit RGB reference)	PFM	TIFF float	Cineon, DPX*	TIFF LogLuv 24 / 32	Radiance HDR	OpenEXR	JPEG-HDR	Windows WDP
Channels	RGB (+Alpha)	RGB	RGB (+Alpha +...)	RGB	L+Index / Lu'v'	RGBE	RGB (+Alpha +Depth +...)	YCC	RGBE
Total Bits per Pixel	24	96	96	32	24 / 32	24	48	variable	variable
Compression	RLE	–	ZIP, LZW	–	RLE	RLE	PIZ, ZIP, RLE, PXR24, ...	JPEG	Wavelet
Covers All Visible Colors (Gamut)	–	–	✓	–	✓	–	✓	✓	–
Colors per EV **	≈2 Million	4.7×10^{21}	4.7×10^{21}	90 Million	1 Million / 33 Million	16 Million	1 Billion	variable	variable
Precision	●○○○	●●●●	●●●●	●●○○	●●○○	●●○○	●●●●	●○○○	●○○○
Dynamic Range (EV)	8	253	253	12	16 / 126	253	30	30	
Application Support Level	●●●●	●○○○	●●○○	●●○○	●●○○	●●●●	●●●○	●○○○	○○○○

I typically use the OpenEXR format mainly because if it is good enough for Industrial Light and Magic it is good enough for me. However Radiance HDR is the default for many applications probably because of the smaller file size. The reason to keep the 32 bit files at least temporarily is to re-tone map the image if desired. Photomatix and others have the capability to batch process a directory of files. In those instances a set of files picked and processed to determine a good tone map preset. The preset is saved then the entire directory is processed with that tone map. If an image can be improved with additional tone mapping then the 32 bit file can be reloaded for further tone mapping.

The other very powerful point is a 32 bit file can be reopened in any tone mapping software. While Photoshop's tone mapping abilities are limited, some of the layers are active and useful for 32 bit files. These layers have all the masking capabilities of other file types. The file can then be reopened in more sophisticated tone mapping software.

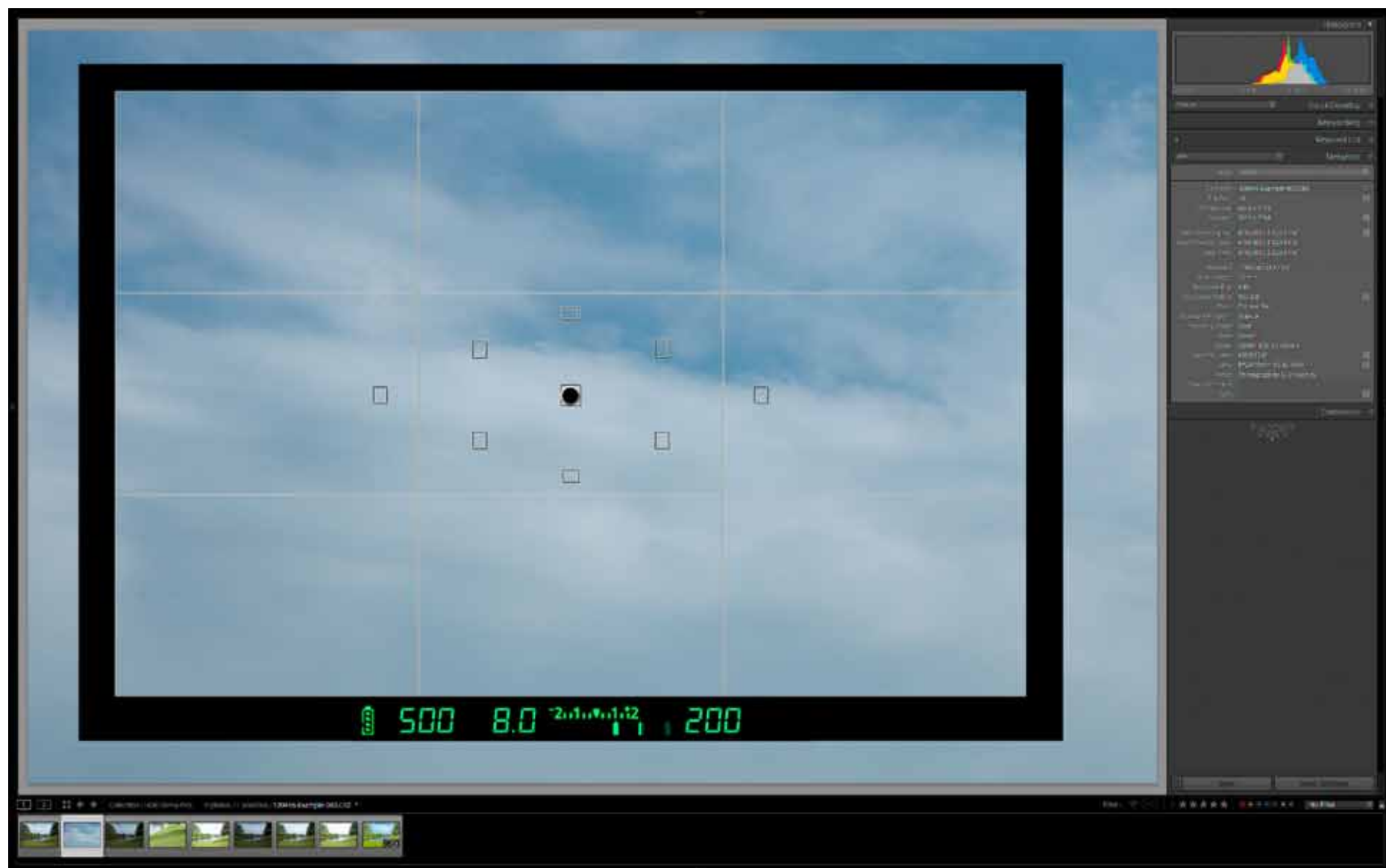
EXPOSING THE HDRI SEQUENCE REVISITED

As discussed above, the camera is set to manual focus, manual exposure, fixed white balance, and spot metering. I took the following images at a park down the street. Below is the opening scene provided for reference. It was shot in mid afternoon and is not a bad picture by itself. This image was exposed using evaluative metering.



Next an EV spacing is picked. A 2 EV spacing is good to start out with. Using spot metering focus on the brightest significant object. If there are clouds set the left most pin on + 1 EV. While the clouds could be set to 0 EV some of the older cameras with only 2 EV maximum intervals may not have enough range. If there is just blue sky set the left most pin to 0 EV. In the desert some of the rocks might be the brightest significant object.

Notice that the histogram on the bottom picture has blocked shadows but has all the detail in the sky with no blocked highlights.

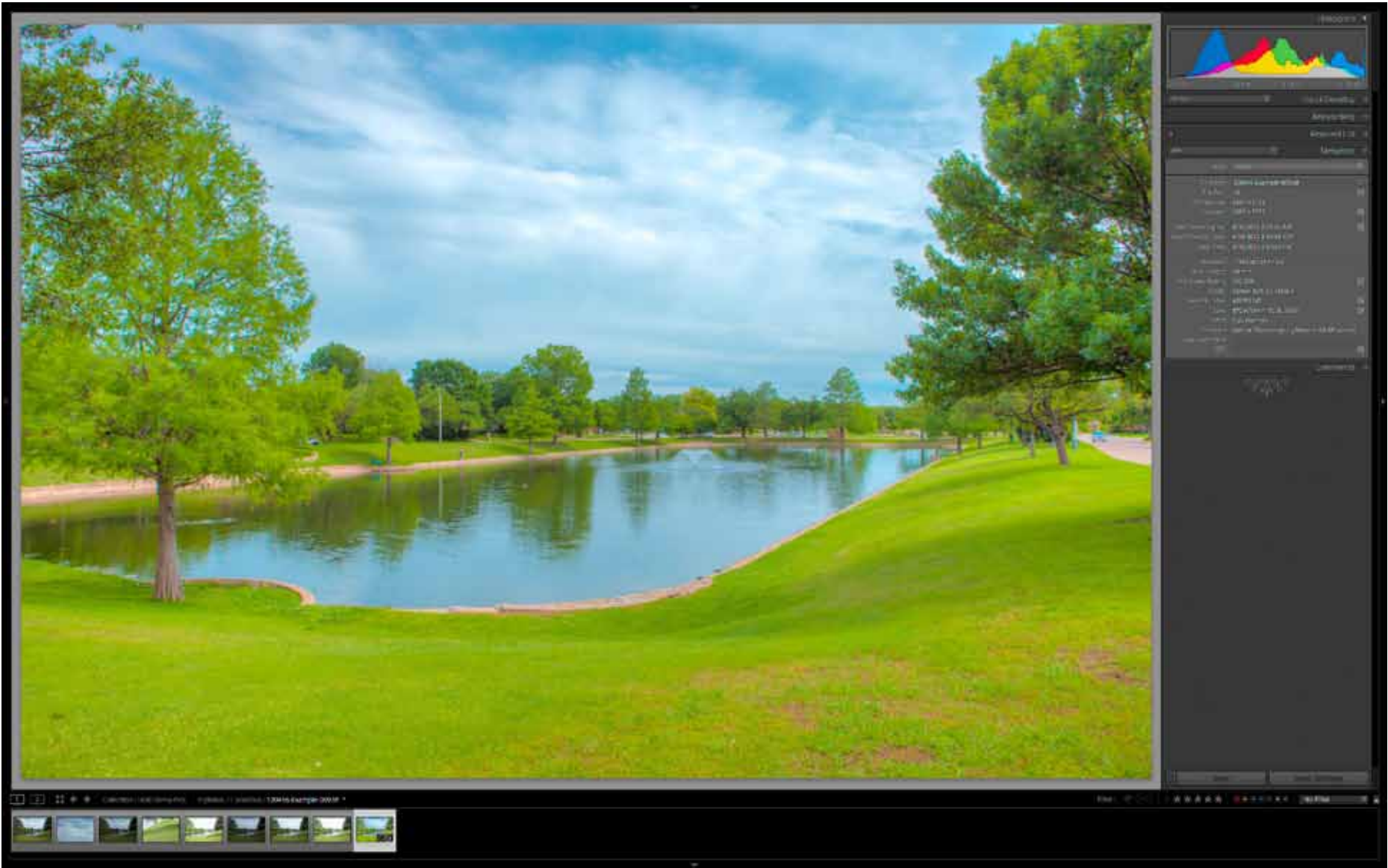


[illegible]

Below is the sequence of exposures. All these images were taken hand held.



Below is the final tone mapped image. Notice all the detail in the clouds, grass and trees have been retained. Pay particular attention to the histogram from the first image and this image. Notice now there are no blocked shadows or highlights. What has happened is the tone mapping process has compressed what was a 14 to 15 EV scene down to about 10 EV.



REFERENCES

Books:

There are many books available. For the most part they are written by photographers with lots of pretty pictures. For all practical intents and purposes they are coffee table books.

The one book I do recommend is The [HDRI Handbook](#) by Christian Bloch. The first edition was published in 2007 which is ancient in photography time. The bad news is the second edition was supposed to be out last November. The good news is Mr. Bloch is actively engaged in California helping develop the HDRI technology for the movie and graphics arts industry. The second edition should be out by the end of summer or early fall.

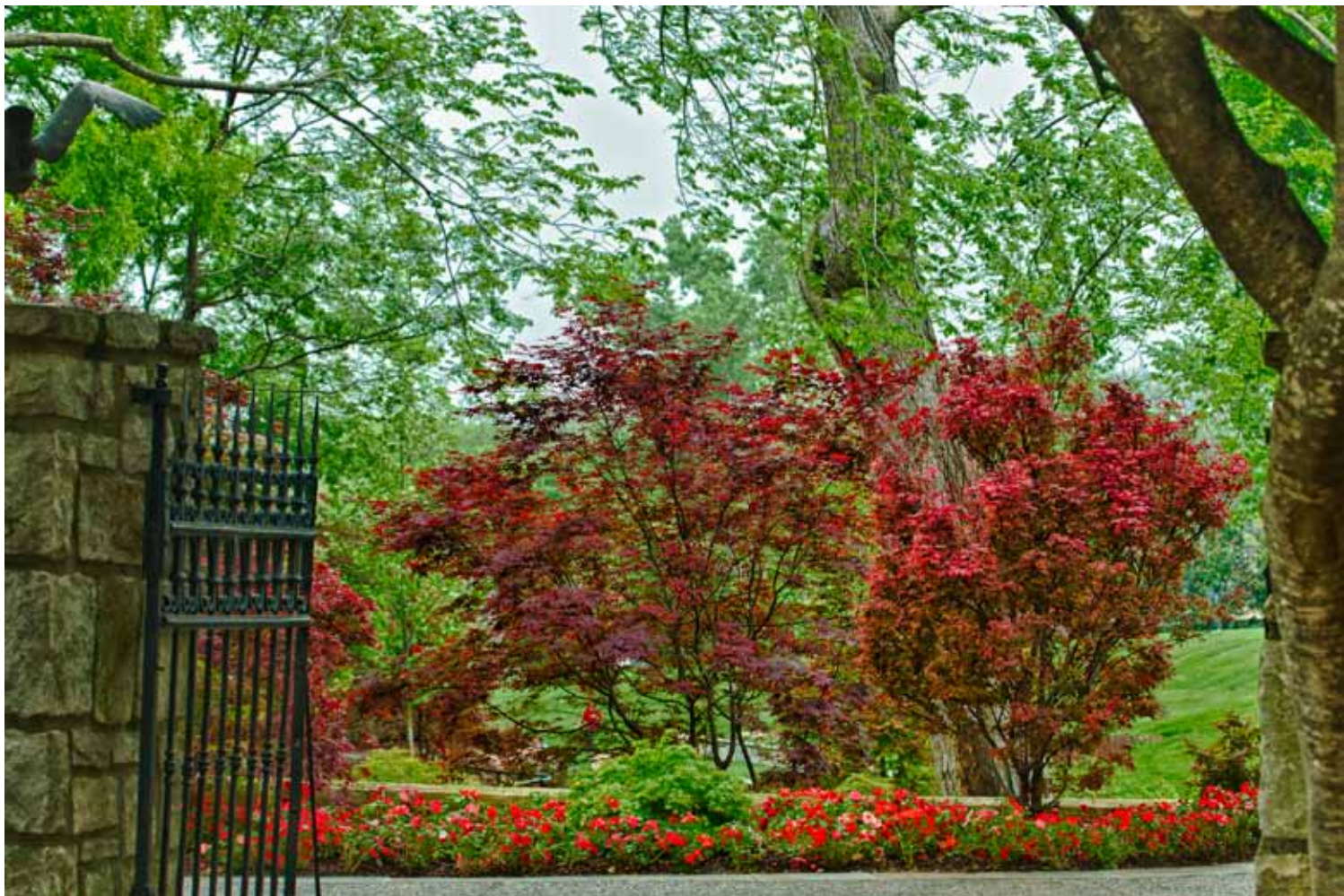
Links:

[Lewis Kemper Photography](#) has much good information. Lewis has a seminar in the Dallas area every year or two. Most important he has [discounts](#) for PhotomatixPro, Nik Software, and Topaz Labs software.

[HDRSoft Photomatix](#): Photomatix is still the gorilla in the china closet. The things most attractive are the presets, ghost removal, flexibility, and the batch processing. There are many excellent tutorials and examples on this site.

[Nik Software](#) has [HDR EfexPro](#) in their suite. They also have many tutorials available.

Considering just HDRI processing, Photomatix, HDR Efex Pro, and Photoshop in that order are the three most used programs. Photomatix for all the attractive features above. HDR Efex Pro because of their incredible U Point technology. Also, HDR Efex Pro has processed some images that Photomatix couldn't such as the image below. The U Point technology made the red oak pop. It was created with only two images. Photoshop is necessary for the 32 bit layers capability and final retouching.



Digital PhotoPro "[A Brief Guide to HDR Photography](#)"

The Canon Learning Center: [How to Capture High Dynamic Range \(HDR\) Images with your DSLR](#)

Unified Color [HDR Expose](#) is another HDRI software package. They have a new version out that I need to try.

Stuck in Customs has many good tutorials along with a 15% Photomatix discount. "[Everything you need to know about HDR Photography](#)"

Little Time Machine "HDR Tutorial: How to create "[High Dynamic Range' images using Photomatix](#)" with another 15% discount

Cambridge in Color is a terrific photography resource. "[HIGH DYNAMIC RANGE PHOTOGRAPHY](#)"

NatureScapes "[The High Dynamic Range \(HDR\) Landscape Photography Tutorial](#)"

HDR Photography Blog [HDR Tutorial](#)

Outdoor Photographer: [*Gadget Bag: High Dynamic Range Software*](#)
[*High Dynamic Range Done Naturally*](#)
[*Tame Your Dynamic Range*](#)
[*HDR \(High Dynamic Range\) Photography In The Maine Woods*](#)

Digital Photopro: [*A Brief Guide To HDR Photography*](#)
[*DPP Solutions: Get The Hyperreal Look*](#)
[*Aesthetics Of XDR*](#)
[*XDR, Part V*](#)
[*Hi-Tech Studio: HDR Software*](#)

Shutterbug: [*The Long Ranger; With HDR Photography, What You Can See Is Now What You Can Get*](#)
[*An HDR Primer; High Dynamic Range Photography For Those Who "Want It All!"*](#)

HDR Photography: [*Top 10 Best HDR Software Review 2011*](#)
[*Mastering HDR*](#)

HDRI Labs: [*Links*](#)
[*Tutorials*](#)