A Quick Guide to Digital Nature Photography

By Neil Losin

Section 1: Getting the Right Exposure

This is the most difficult – and the most important – section of the guide. Controlling exposure is the most fundamental skill in photography. Once you master exposure, the rest is easy.

1.1 – Sensitivity: When photographs were captured on film, instead of digitally on a CCD or CMOS sensor, the ***sensitivity*** of the medium was fixed. A film's sensitivity is often referred to as its ***speed*** or ***ISO*** (the latter is an acronym for International Standards Organization, a group that defines industrial standards in many fields). Film cameras could read the ISO speed from a film canister, and would "know" whether the film was ISO 100, 200, etc.

Higher ISO ratings indicate greater sensitivity to light, and ISO ratings have a simple linear relationship with sensitivity. For example, an ISO 400 film is four times as sensitive as an ISO 100 film, and therefore requires only ¼ as much light to form an image.

In the digital age, we can adjust the light-sensitivity of our camera from one shot to the next. A typical range of ISO sensitivity is ISO 100 – ISO 1600, but some professional cameras go much higher (the Nikon D3s, for example, can be set as high as ISO 25600). Your camera's ISO adjustment might be controlled with a single easy-to-access button on the camera body (this is the case for most SLR cameras), or it might be buried deep in some sub-menu. Consult your camera's manual to determine how to adjust its ISO sensitivity.

1.2 – Aperture: Two factors determine how much light reaches a camera's sensor: aperture and shutter speed. **Aperture** refers to the size of the opening through which light passes inside the lens. Somewhat counter-intuitively, *large apertures are indicated by small numbers*, like f/2.0 or f/2.8. This is because aperture is *approximately* defined as the lens' focal length divided by the diameter of its front ("objective") lens. For example, a 300mm f/4 lens must have an objective lens *at least* 75mm in diameter. Canon's 300mm f/4L IS lens actually has an objective element that is 77mm in diameter, so it satisfies this requirement.

Aperture can be discussed in terms of ***stops***. Each stop is equal to a doubling or halving of the amount of light hitting the film (or sensor). Here is a list of the "full" stops:

f/1.0, f/1.4, f/2.0, f/2.8, f/4, f/5.6, f/8, f/11, f/16, f/22, f/32

Notice that the number designating each stop is about 1.4x the previous stop. It's no coincidence that $(1.4)^2$ is approximately 2. Each time you increase the *diameter* of the aperture by a factor of 1.4 (e.g. from f/2.8 to f/2.0), you *double* the amount of light entering the camera.

You might be thinking: the size of the objective lens is constant, so how can you adjust the aperture without changing lenses? Inside each lens is an *iris diaphragm* that dilates and constricts like the human iris to regulate the amount of light entering the camera. On older SLR cameras, the iris diaphragm can be adjusted by an aperture ring at the base of the lens, and in more modern cameras it's controlled through the camera body itself. Many cameras allow the photographer to adjust the aperture in 1/3-stop increments, so you have finer control. For example, instead of jumping straight from f/5.6 to f/8, you can choose f/5.6, f/6.3, f/7.1, or f/8.

1.3 – Shutter speed: **Shutter speed**, or exposure duration, is the amount of time the camera's shutter remains open, allowing light from the lens to reach the film (or sensor). The numbers

Box 1: Raw versus JPG capture:

Many cameras, including all digital SLRs and some point-and-shoots, allow the photographer to capture "raw" or JPG images. The exact file format varies by manufacturer; Nikon's raw files have a .nef file extension, while Canon's have a .cr2 extension. To save a raw image, your camera records each pixel's data straight off the sensor, along with camera settings recorded at the instant of capture. To save a JPG, the camera takes an additional step: it processes these raw pixel data into the JPG file format, which is a compressed format. JPG images take up less room on your memory card than raw images, but there are many practical advantages to capturing raw images, if your camera allows it:

1) Raw files are lossless, meaning there is no destructive compression applied to the image data. When your camera saves a raw file, you have access to every bit of data that your camera captured during the exposure. With a JPG file, even at the camera's highest JPG quality setting, your camera is throwing some data away right at the outset.

2) Raw files have a greater bit depth (12-14 bits per color channel) than .jpg files (8 bits per color channel). In practice, this means that compared to a JPG, a raw file captures finer gradations of color. You can also recover more detail from an under- or overexposed area in a raw file than from a JPG file.

3) You have far greater control over image post-processing with a raw file than with a JPG. For example, suppose your camera chooses an inappropriate white-balance setting when interpreting the data of the sensor. If you are recording JPG files, there is no going back to the original pixel data. With a raw image, however, the original pixel data always remains intact; settings like white balance, saturation, and sharpening can all be adjusted after the fact. Rather than being applied directly to the image data, as in a JPG, these settings are simply stored in the raw file's *metadata*. The process of changing how the image data are interpreted and displayed – without manipulating the underlying data – is called *non-destructive editing*, and it is a signature of the raw workflow.

One disadvantage of raw capture is that each camera manufacturer has their own proprietary raw file format, which means there are few software programs that are compatible with every camera's raw files. Luckily, Adobe Photoshop and a handful of other programs can deal with just about any camera's raw files. Ultimately, when your images appear in print or on the web, however, you will still want to convert them to a more universally recognized format like JPG or TIF – this is easier for editors and web browsers.

your camera uses to display shutter speed are straightforward: a shutter speed of 800 or 1/800 means that the shutter will remain open for 1/800th of a second; a shutter speed of 60 or 1/60, 1/60th of a second. If the shutter speed is longer than 1 second? Many cameras display numbers followed by the second symbol ("). For example, 15" means 15 *seconds*, not 1/15th of a second.

The relationship between shutter speed and the amount of light striking the film (or sensor) is simple – the amount of light is exactly proportional to the amount of time the shutter is open. Like aperture, we can talk about shutter speed in terms of "stops." For example, a shutter speed of 1/400th allows one stop more light than a shutter speed of 1/800th. Faster shutter speeds are often desirable in wildlife photography; birds and other animals are active, and faster shutter speeds enable the photographer to freeze fast action. Fast shutter speeds are less crucial for landscape and macro work, where the subject (usually) isn't in much of a hurry (see Fig. 1).

Figure 1: Different shutter speeds achieve different visual effects. *Left:* Using a very fast shutter speed, this Royal Tern is effectively frozen in time as it flies by (ISO 200, 1/2000s at f/7.1). *Right:* Using a much slower shutter speed, the rushing water of this Colorado stream is rendered as a smooth, flowing cascade (ISO 200, 0.8s at f/22).

Shutter speeds can usually be adjusted in 1/3 stops, just like aperture. For example, you aren't just limited to shutter speeds like 1/125th and 1/250th of a second. If you want to use something in between, you can set your shutter speed at 1/125th, 1/160th, 1/200th, or 1/250th.

1.4 – Depth of field: Why not use your maximum aperture all the time (i.e. shoot ***wide open***), and take advantage of the highest shutter speed that conditions allow? To answer this question we need to consider a new concept, ***depth of field***. Depth of field refers to the range of camera-to-subject distances that appear in focus in a single image. Imagine you're shooting a portrait of a German Shepherd dog, using a Canon 300mm f/4 lens. You focus carefully on its nose and take a picture. If you shot wide open (i.e., at f/4), then when you look at the picture on the computer, you will find that, although the dog's nose is in focus, the rest of its face is completely soft! This is because while you focused accurately on the nose, the rest of the dog's face was farther away from the camera, and fell outside the depth of field for this lens at f/4. You'll need to "stop down," or shoot with a smaller aperture, to get the dog's whole face in focus. Or, take a picture of a Pug instead. The depth of field also affects how "in-focus" the background appears (see Fig. 2). In the "Lenses" section below, we will discuss depth of field in greater detail.

1.5 – Tradeoffs: using sensitivity, aperture, and shutter speed to get the exposure you want: As you've probably realized by now, sensitivity, aperture, and shutter speed are intimately linked. If you change one, you've got to change another to maintain the correct exposure. If you stop down your aperture from f/2.8 to f/4, you need to decrease your shutter speed by a stop (e.g. from 1/125th to 1/60th), or increase your sensitivity (e.g. from ISO 200 to ISO 400). Doing all of this manually takes time. Luckily, your camera can measure light and set the proper exposure automatically. In the next few sections we will discuss how your camera measures light, how it can be fooled, and how you can take the reins when necessary and use partial or full manual control to override your camera's autoexposure system.

1.6 – The meter: The camera's ***meter*** measures the intensity of light. While some photographers use a dedicated external light meter (and there are some advantages to this method), most use their camera's built-in meter, which measures light coming through the lens. The simplest type of through-the-lens meter (seldom found in modern cameras) is an averaging meter, which measures the average intensity of light over the entire frame and calculates the proper exposure

Figure 2: Hugo, my Boston Terrier. I took these photos to show the effect of aperture on depth of field. *Left:* 1/5000s at f/2. *Right:* 1/80s at f/16. All other settings (ISO, etc.) are identical. Both photos were taken with the Canon 5D Mark II and Canon 135mm f/2 lens. While Hugo's face is sharp in both images, the f/16 image has a far greater depth of field; even Hugo's front paws are outside the depth of field in the left image!

based on this average. Newer cameras use other, more sophisticated metering systems, and many cameras allow the photographer to switch the metering mode at any time.

1.6.1 – Spot metering: The spot meter measures light only in one small part of the frame, usually located in the center. The "spot metering circle" generally only covers 3-5% of the frame, so it allows the photographer to measure the brightness of a small-in-the-frame subject accurately, and base the exposure of the whole scene on that subject. The rest of the frame does not influence the spot-meter reading at all.

1.6.2 – Center-weighted average metering: This metering mode measures brightness in two areas of the frame: a central circle, somewhat larger than the spot metering circle (covering perhaps 15% of the frame area), and the rest of the frame that surrounds that central circle. As the name suggests, the meter weights the central reading more heavily, usually giving a

Box 1: How sensitivity affects picture quality

The ability to change the sensitivity of your medium (the sensor) at any time is one of the great advantages of digital photography. If your shutter speed is too slow at ISO 100, you can simply crank up your camera's sensitivity to ISO 400, rather than having to wait for a new roll of film. So why not shoot at high ISO all the time? Because in order to make the image sensor more sensitive, the camera essentially has to amplify the signal more heavily. This results in a higher level of ***noise***, which can manifest itself as a "grainy" look, blotchiness, or spurious color, especially in shadowed areas (see Fig. B1). Therefore, it's generally a good idea to shoot with your ISO as low as you can manage in any given situation. On the other hand, a grainy picture is better than no picture at all, so don't be afraid to take advantage of your camera's high-ISO capabilities when necessary. *Note:* Cameras with smaller sensors (like most point-and-shoots) suffer from much worse image degradation at high ISO settings than digital SLRs, which have much larger sensors.

Box 1, continued

Figure B1: Digital noise increases at high ISO. I took the same photo at ISO 100 and ISO 1600, using my Canon 5D Mark II. The images look alike at a distance, but under closer scrutiny the ISO 1600 image shows much more noise. The ISO 100 image will make better large prints, but the ISO 1600 image is still quite usable for small prints, PowerPoint slides, web images, and other similar uses. Incidentally, this camera performs quite well at high ISOs, but you should test your own camera's capabilities for yourself. Figure out how high you can set your ISO before the image deteriorates to an unacceptable level.

weight of 75% to the center portion and 25% to the outer portion of the frame. For fairly large, centered subjects, this can be a useful tool.

1.6.3 – Evaluative / matrix metering: Most modern cameras have some kind of evaluative meter. These meters measure light across the whole frame (like the averaging meter), but they break the frame into many small pieces. From all of this data collected by the meter, the camera compares the *pattern* of brightness across the frame to a database of stored "scenes," and tries to figure out what you're photographing. For example, if the camera determines that the upper area of the frame is bright, while the lower area is dark, it might decide that you're photographing a scene with a bright sky and dark land. In a case like this, a good evaluative meter will try to expose the land correctly, and not worry too much about whether the sky ends up a bit overexposed. In general, the evaluative meter is pretty smart – it gives good results in a wide variety of conditions, and it's a good everyday metering mode.

1.7 – Exposure modes: Modern cameras have several exposure modes, usually including ***manual***, ***aperture priority***, ***shutter priority***, and ***program auto***. They differ in *the amount of control they give the camera* in deciding what exposure to use.

1.7.1 – Manual mode: In manual mode, the photographer sets both the aperture and shutter speed manually. The camera uses its meter to decide how much light *should* be allowed to hit the sensor, and tells the photographer whether the aperture and shutter speed manually set by the photographer will under- or overexpose the image. There is usually a scale visible in the camera's viewfinder that indicates how far under- or overexposed the image will be (as estimated by the camera). If you fully trust the meter, adjust your aperture and shutter speed so the viewfinder indicator reads "0."

The remaining three modes are all considered “autoexposure” modes:

1.7.2 – Aperture priority: In this mode, the photographer sets the aperture manually, and the camera adjusts the shutter speed automatically to expose the image correctly.

1.7.3 – Shutter priority: In this mode, the photographer sets the shutter speed manually, and the camera adjusts the aperture automatically to expose the image correctly.

1.7.4 – Program auto: This mode gives all control to the camera. The camera decides what shutter speed *and* aperture to use. To decide what combination of aperture and shutter speed to use, it not only evaluates the amount of light, but also things like the focal length of the lens in use. For example, the camera will tend to use faster shutter speeds and wider apertures with long lenses, because long lenses are more prone to showing the effects of camera shake at lower shutter speeds. This is a good mode for people who don’t know much about photography, but in general you can probably do without it.

1.8 – Tonality and outsmarting your camera: It is important to understand how your camera's autoexposure system works: **it wants to make everything mid-toned** (see Fig. 3). “Mid-toned” objects reflect more light than black objects, but less light that white objects. Specifically, your light meter is calibrated to expose all scenes so that they appear as bright as an 18%-reflective gray object. Some photographers carry a “gray card” with them in the field to help them set manual exposures. They place the gray card in similar light to their subject, meter the card, set the exposure, then photograph their subject at the metered exposure.

One implication of this mid-tone bias is that you have to be aware of what you’re shooting, because your meter can be fooled. If you photograph a blank white wall; your camera will *underexpose* the wall to make it gray. If instead you photograph a featureless black wall, your camera will *overexpose* the wall to make it gray. If you photograph a green deciduous forest, which has about the same reflectance as an 18% gray surface, then the camera will expose the scene correctly – but not every natural scene is so cooperative!

Figure 3: The tonality of the subject affects the meter reading. In these photos, I used an upper autofocus sensor to focus on my wife’s face, which placed the spot meter on her shirt. *Left:* metering the black shirt, the exposure was 1/60s at f/5.6; the meter tried to make the black shirt a mid-tone, and therefore Liz’s skin was badly *over*exposed. *Center:* metering the mid-toned shirt, the exposure was 1/400s at f/5.6; the meter correctly rendered the mid-toned shirt as a mid-tone, and therefore the entire scene properly. *Right:* finally, metering the white shirt, the exposure was 1/2000s at f/5.6; the meter tried to make the white shirt a mid-tone, so Liz’s skin was severely *under*exposed. *Note:* I used the camera’s spot meter for illustrative purposes – because it measures light in such a small area, it is somewhat easier to “fool” than the evaluative meter. The evaluative meter would have made similar, but less drastic mistakes. How do you avoid these exposure errors? Meter something mid-toned, or use exposure compensation.

Luckily, even in autoexposure modes, you *do not* have to depend completely on the camera's meter to expose the scene properly. The camera allows you to adjust the exposure above or below the metered value using ***exposure compensation***. Exposure compensation can be adjusted in 1/3 stops (i.e., +1/3, -1 1/3, and so forth). When you're in aperture priority, the camera makes exposure compensation changes by adjusting the shutter speed (so the manually selected aperture remains the same); likewise, when you're in shutter priority, the camera adjusts the aperture to make exposure compensation changes, to keep the manually selected aperture the same. Here are some situations where you won't be happy with the camera's metered exposure:

1) You're photographing a white bird against a mid-toned background. Unless the bird takes up most of the frame, the camera will usually expose for the background, resulting in a severely overexposed bird. Dial in some negative exposure compensation (try -1 to start), and check the results on your camera's LCD screen.

2) You're photographing a crow against a light or mid-toned background. Again, the camera will usually expose for the background. To get the best exposure, you should dial in some plus compensation, otherwise you'll lose detail in the blacks.

3) You're photographing a bird flying in a clear blue sky. Blue sky is substantially lighter than 18% gray, so you need to dial in some plus compensation. If the sky is a hazy blue, dial in even more, because a hazy sky is lighter than a clear blue one.

1.9 – The histogram: Digital cameras give you instant feedback on your exposures via the ***histogram***. The histogram plots the range of tonalities, from pure black to pure white, along the

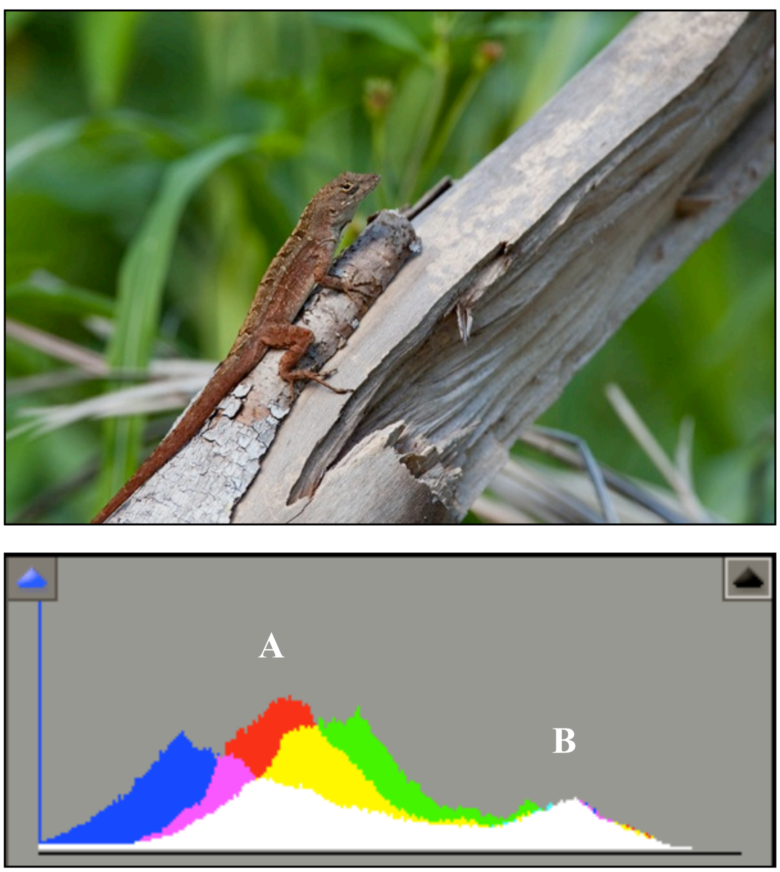

Figure 4: An image (*top*) and its histogram (*bottom*). This style of histogram, which shows each color channel (red, green, blue) separately, is shown in Adobe Camera Raw when you open a RAW image. The large peak (A) toward the left end of the histogram represents the grassy green background that occupies most of the frame. The smaller peak (B) on the right represents the brighter areas of the grayish log on which the anole is perched. You can tell the larger left peak represents the green background because the green channel is more intense than the other two channels (i.e. the green peak is farther right in the histogram). By the same token, the right peak must represent the gray log, not only because the trunk is brighter than the background, but also because all three channels in the histogram peak at about the same value – just what you'd expect for a gray object.

x-axis, and indicates how many pixels fall into each brightness bin on the y-axis. In a correct exposure, most of the pixels in your image will fall fairly close to the middle of the histogram (see Fig. 4). You want to avoid having any pixels at the rightmost and leftmost extremes of the histogram – these pixels are outside the camera's "dynamic range" (i.e. the range of tonalities it can capture in a single image) and they contain little or no image detail as a result.

If you expose a typical mid-toned scene properly, you'll get a histogram that looks something like a normal (Gaussian) curve. If you shoot a gull swimming in the ocean, you might see one large peak toward the left (dark) end of the histogram (representing the dark blue ocean water occupying most of the frame), and a smaller peak toward the right (bright) end of the histogram (representing the white and light-gray plumage of the gull).

After you shoot a scene with a tricky exposure, check the histogram. If you've "blown out" (overexposed) the highlights or "blocked up" (underexposed) the shadows, you should be able to see it in the histogram. Some cameras can display each color channel (red, green, and blue) in a separate histogram. Many cameras also have the option of displaying blown-out highlights as blinking areas on the LCD screen's preview image. If your camera has this feature, you can see when you've overexposed the highlights of an image even without looking at the histogram.

1.10 – Conclusion: Exposure is the most technically demanding aspect of photography. If you've made it this far, you know more about exposure than many photographers do! Re-read the previous section, several times if necessary, until you feel comfortable with all of it. Good luck!

About the author: I am a biologist and photographer. I'm currently pursuing my Ph.D. in UCLA's Department of Ecology and Evolutionary Biology, where I study territorial behavior in invasive lizards. When I'm not doing science, I love taking photographs of nature (especially birds and other wildlife) and documenting the work of other scientists who study nature. I have been a photographer for about ten years, and my work has been recognized in international photography competitions and published in books and magazines worldwide. To learn more, please visit my website: www.neillosin.com. Thanks!

Contact me: With your feedback, positive and negative, I can improve future versions of this guide. If you have comments about the guide, or you simply want to discuss photography, you can e-mail me at neil.losin@gmail.com.