

Increase Depth of Field and Image Sharpness with Focus Stacking

By John Gerlach

www.gerlachnaturephoto.com



Figure 1 The bent trillium grows close to the ground. To avoid including many background distractions, I focused stacked this image by shooting 7 images at slightly different distances until the entire blossom was sharply focused. I used f/5.6 to produce a far less distracting background and covered the depth in the flower by stacking the seven images.

All photographers have problems getting sufficient depth of field and superb image sharpness simultaneously because it is a trade-off. The sharpest aperture on the lens is typically two to three stops smaller from the maximum aperture on the lens. With a 200mm f/4 lens, for example, the sharpest apertures fall in the f/8 to f/11 range. Due to the laws of physics, though, the greatest depth of field is always at the smallest aperture (largest f/stop number) which is usually f/22 or perhaps f/32. In simple terms, these f/stops refer to the tiny hole in a lens called the aperture. Due to the wave nature of light, as the hole it passes through gets smaller, a larger percentage of the light touches the edge of the hole and bends. This bending is called diffraction and causes a loss of sharpness. It is a huge problem! I recently tested the diffraction on my Canon 180mm macro lens for a new book—*Close Up Photography in Nature*. I was horrified by how bad it is at f/32—even f/22 produced underwhelming results. Although, in theory, the depth of field is optically greater at f/32, the overall image sharpness is far less than f/11 due to diffraction. Although photographer opinions vary, I feel that f/32 is worthless on this lens and probably most other lenses as well.

Stopping the lens all the way down creates other problems. Shooting with f/32 requires a shutter speed three-stops slower than f/11. This slower shutter speed becomes a problem when photographing handheld or fighting a persistent breeze that is blowing the subject. Smaller apertures not only increase the depth of field covering the subject, but they bring details in the background more in focus which often cause unsightly distractions. And don't forget about flash. Stopping the lens down more makes it increasingly difficult for the flash to light distant objects. This probably isn't a problem in close-up photography, but it is a frequent problem in landscape photography.

Tilt/Shift Lenses

Normally, you must use superb technique and align the most important plane of the subject with the plane of the camera's sensor to achieve the greatest overall sharpness. However, this is not always the case. Canon and Nikon offer several lenses that bend or shift. Lenses that bend are often called tilt or perspective control lenses and they do amazing things. When the lens is tilted exactly the right amount, and in the proper direction, it is possible if the angle isn't too extreme to make the plane of focus align perfectly with the plane of the subject without having both parallel to each other. For example, it is easy to make a tilt lens sharply focus a field of tulips or wildflowers. Tilt lenses work great and I have used them for decades with wonderful results.

However, tilt and shift lenses aren't for everyone. They are expensive and there is a learning curve to successfully using them. The written instructions that come with them are difficult to comprehend, though, I find it is easy to show workshop clients how to use these lenses. However, problems include focal-length choices are limited and they only help improve sharpness in one plane. If you align the plane of focus with the flowers in a field, it is easier to get all the blossoms sharply focused, but their stems go more out of focus because they are in a plane that is almost at right angles to the plane of the blossoms.

Focus Stacking to the Rescue

Focus stacking enables you to achieve unlimited depths of field in all planes with the sharpest apertures on your lens. To keep things simple for now, focus stacking requires you to shoot a series of images where the focus slightly overlaps from one image to the next. This stack of images, where a small slice of the subject is sharply focused in at least one of the images, is combined with focus stacking software. This software aligns the images and selects the sharp portions in each image and merges them into a single image where everything is pleasingly sharp. If an area in the image is not sharply focused in any of the images, then it remains out of focus in the final image.

This technique is starting to become known and the software for processing stacks of images continues to improve as photographers gain experience with it and offer feedback to the software gurus who create it. Focus stacking offers many advantages. It is probably the most powerful new tool to come along in my forty-year photography career.

1. Easy to do
2. Relatively inexpensive
3. Offers unlimited depths of field
4. Works with any lens than can be manually focused
5. Sharply focuses all planes
6. Enables keeping the background completely out of focus while the subject is entirely in focus
7. Enables faster shutter speeds
8. Helps the flash light objects at distances
9. Produces images that are unique
10. It is fun to do

And some (minor) disadvantages:

1. The subject must be still
2. Works best on a solid tripod
3. It takes more time to shoot the images
4. The images must be combined with software
5. Higher magnifications (1x and greater) are more easily done on a focusing rail that you need to purchase and carry with you

Software Choices

Several programs do focus stacking, and these include Photoshop, CombineZM, Zerene Stacker (zerenesystems.com), and Helicon Focus (www.heliconsoft.com). I use Helicon Focus and work with it easily, so it must be easy, as I am a known computer “disliker.” I run my stacks through Helicon Focus easily and quickly.

The Focus Stacking Process

Select the Subject

A completely still subject is best for this technique. Subjects that wiggle in the breeze or move on their own—creeping caterpillars—don’t work. Flowers, mushrooms, frost, lichens, frogs, or naturally chilled insects on cool mornings all make excellent prospects. Often, I use a Plamp to hold the subject as still as possible in case the air is moving the least little bit. The Plamp is attached to a light stand and the other end is attached to the object that is supporting the subject. Sometimes a little movement in the subject isn’t a problem. When I was photographing a jumping spider on a rock outdoors on a cool morning, the spider raised a couple of its front legs. It wasn’t a problem because I had already shot 25 images. I had covered most of the spider and was focused on its rear legs. The focus stacking software looks for sharp areas. Since the legs that moved during the series of exposures were completely out of focus, the software ignored it and no movement was visible in the final result.

While focus stacking works well for close-up and macro images, it also works for anything else that holds still. If you have a motionless animal—even an elephant or a flock of shorebirds resting on the beach—focus stacking works. Landscapes lend themselves to this wonderful technique, too. Imagine shooting in a slot canyon where there is a near foreground and more distant background. Now you can focus stack your way all the way through the depth that must be captured. You could even shoot HDR and focus stack a set of images at the same time. You can also combine focus stacking and panoramas. It is even possible to combine focus stacking, HDR, and panoramic. The possibilities are endless.

Focus stacking is incredibly useful in low-light photography. Rather than trying to shoot a sharp image of Delicate Arch with a near foreground in Arches National Park at dusk when the light is dim with a single exposure using $f/22$ at eight seconds, it is easier to shoot a focus stacked set of images using the sharpest aperture on the lens— $f/8$ for instance. This means the exposure time is a more reasonable and a less noisy 1 second at $f/8$, rather than 8 seconds at $f/22$.

Focus stacking enables you to solve depth of field problems in the landscape that cannot be solved by stopping down or using the tilt mechanism found on some perspective control lenses. I remember trying to photograph the reflection of Yosemite's El Capitan in a Yosemite Valley meadow. If I focused on the reflection, the flowers surrounding the pool of water were severely out of focus. If I focused on the flowers, the reflection was out of focus. I never did get them both as sharp as I wanted because the flowers and El Capitan are so far apart in distance that depth of field can't cover it. Now, with focus stacking, it is easy. Focus on the flowers, select $f/11$, meter, and shoot. Then focus a little bit further away, perhaps on the far side of the pool, and shoot another image. Then focus on the reflection in the pool and shoot another image. Run the focus stack of images through the software program to get both the flowers around the pool and the reflection perfectly sharp. It's like magic!

For years I wanted to shoot patterns of lily pads when they are surrounded by fall color reflections. If I focus on the lily pads and stop down to get all of them sharply focused (and they still aren't perfectly in focus), the colorful reflections also show more detail and become distracting. My goal is to sharply focus the lily pads but keep the reflections as out of focus swirls of color. If I shoot wide open, I get the swirls of color, but only some of the lily pads are sharply focused because the depth of field is too limited. I have done some shots like I envisioned by using a Canon 90mm tilt and shift lens. By tilting the lens to make the plane of focus coincide with the plane of the lily pads and shooting wide open, I get the desired effect. Unfortunately, most of the lily pads require a longer focal length lens to optically reach them—since I can't walk on water and barely swim, getting closer is problematic. With focus stacking, you can use any lens—even a 300mm or 500mm—and shoot wide open. Focus on the nearest spot that you want in focus and shoot. Then focus a little bit further away and shoot another image. Keep this up until the furthest object that you want in sharp focus in the background is in focus. Process the stack and all the lily pads are in focus and the color reflections remain unfocused swirls of color!

Exposure

Use Manual exposure when shooting multiple images that will be combined into one. Don't allow the exposure to change at all within the set of images. This means the ambient light or light from a flash must also stay the same. Set ISO 100 or 200 to minimize noise. What about the aperture or f /stop? Set the aperture somewhere between $f/8$ and $f/11$. This is counterintuitive. Since the goal is to extend the depth of field, why not use $f/22$ or $f/32$? A good question—with a crucial answer! There is no point in stopping down to small apertures to gain depth of field that will be covered in the stack of images anyway and suffer the image softening effects of diffraction. The sharpest apertures on your lens are probably around $f/8$ to $f/11$ and these "crisp" apertures offer the dual advantages of delivering excellent sharpness while enabling the use of faster shutter speeds. Finally, adjust the shutter speed until the optimum exposure has been achieved as shown by the histogram and/or highlight alert. I prefer the

highlight alert. When the first blinkies appear during playback of an image just shot, that is what I normally use. Since I shoot RAW files only, I know the highlights are not overexposed.

Focus

Use manual focus. Autofocus modes are too difficult to do when small focus changes are needed. Decide where you want sharp focus to begin. For example, suppose a jumping spider is quietly perched on a stone. Do you want all the stone in the foreground sharp or only the stone slightly in front of the spider? It is your choice. You don't have to make everything sharp in the image—only those portions where you want sharp focus. When you have determined the starting point for sharp focus, shoot the image using excellent technique—tripod, remote release, and mirror lockup. (My technique has changed recently for the better. Now I shoot images using the live view mode and the Touch Shutter set to Sensitive on my Canon 5D Mark IV. To avoid any vibration from gently touching the Touch Shutter, I set the camera to the 2-second delay self-timer. Shooting in live view eliminates the dual problem of mirror slap and shutter shock. Focus the lens a tiny bit deeper into the scene and shoot another image. Remember, the increment changes don't have to be the same and you do want some overlapping sharp areas between consecutive images. Manually change the focus only enough until you see it change and shoot another image. Keep shooting and focusing deeper into the scene until the furthest spot in the image where sharp focus is desired is captured. Some subjects with limited depth only require a few images and some demand fifty or more, but this depends much on magnification. I commonly shoot stacks of 30 to 40 images when photograph a tiny jumping spider or flower blossom. Larger objects need fewer images to cover the desired depth of field. Keep in mind the greater the magnification, the shallower the depth of field at any aperture and the larger your image stacks must be to cover the portion of the image where sharp focus is desired.

Focusing Strategies

I use two methods to change the focus. With my 180mm macro lens, I typically turn the focusing ring on the lens a little at a time between shots. It is quite easy to do and works well. Just be careful to avoid bumping the tripod-supported camera because it may cause a change in composition preventing images from aligning well—although most focus stacking software programs can align images if they aren't too far out of alignment. A focusing rail is an easier way to accomplish focus changes, especially at magnification from life-size and greater. The camera is mounted on the rail. Turning a knob moves the camera back and forth in tiny increments. The focusing rail is by far the best way to work when you approach and exceed life-size (1x or 1:1) magnification. Indeed, with my favorite lens for high-magnification images—the Canon 65mm macro—the focus rail must be used because this lens has no focus ring. Instead, the ring changes the magnification to cover a range of 1x to 5x. Some stack shooters think that one focusing way is better than the other. However, I have not yet found a reason to use one focus method over the other as they both seem to work equally well. To summarize, there are two ways to change the focus.

1. Change the focus by manually turning the focus ring on the lens.
2. Mount the camera or the lens tripod collar if it has one on a focusing rail and change the focus by moving both the lens and the camera back and forth along the rail.
3. And there is a third way that I am not a fan of most of the time. Some prefer to use their camera's Touch Screen to autofocus the lens on different portions of the scene. This can work if the spots where focus should be are rather few in numbers and easy for the autofocus mechanism to find. I just do it manually, as I find autofocus is more unreliable. I do better with manual focus.

Lens Choices

Focus stacking works with any lens for landscapes and close-ups. You could take a 24mm lens and focus on an arch in California's Alabama Hills and then focus on the Sierra Nevada Mountains far behind the arch and merge the two together. In close-up photography, any macro lens works nicely. To shoot high magnifications, use a shorter macro lens with extension tubes to reach magnifications greater than life-size. Some of you may be surprised who have read my books and articles that I don't automatically go to my long focal-length 180mm macro lens. Short macros work at high-magnification. The wide angle of view of a 50mm macro isn't that big of a problem because the depth of field at $f/11$ or any aperture is so tiny at life-size and greater that no object distractions appear in the background because everything is completely diffused from being so far out of focus. However, bright spots from the sky can still be a problem, so pick a background that is entirely a single color and brightness.



Figure 2 A nine shot focus stack of Cosby Creek in the Smoky Mountains. I used $f/8$, manually focused from the nearest point at the bottom of this image and continued on to the top. As it turned out, I focused two more images further than I needed to and the top of the image went steadily out of focus. No worries, though, as I simply deleted the two unnecessary images from the stack.

Processing the Stack of Images

Helicon Focus

Using Canon's Digital Photo Professional software, I download the images from my CF card to a 3TB external hard drive. I typically shoot many stacks of images and mark the beginning and ending of the stack by photographing my hand. Using Canon's software, I put each separate stack of images into its own folder. For example, I recently photographed the rocky steams at Smoky Mountain National Park near Gatlinburg, TN. Under the Smokies folder, I have many subfolders labeled FS#1, FS#2, and so on. I use the letters FS to indicate the folder contains a set of images that are focused stacked. The unique numbers – 01, 02, 03, 04 - merely separate the different sets of stacked images. Then I open Helicon Focus 6.7.1. When the window opens, on the upper left side of the screen, press **File**. Now press **Open Images**. This lets you view all the folders in your computer or attached in hard drives or even your camera's memory card. Find the stack of images that you wish to process. When you select them and press **OPEN**, they appear in a window of source images at the upper right side of the screen. Press the Render button in the lower right corner of the screen and the software takes a minute or two to process the images. Eventually, an image appears that incorporates all the sharp portions of each image in the stack into a single image with tremendous depth of field. Give this file a name and save it. Under the Parameters button, there are three methods one can use to process the stack. These methods include:

A w.average

B depth map

C pyramid

Some methods work best with certain images. For example, jumping spiders have lots of detail and method C works best. I normally run each image stack through Method B but do use Method C when there is lots of tiny details.



Figure 3 This is the interface of Helicon Focus. Notice the File at the top left of the page. Click on that and it lets you retrieve your images. When the images are selected and Open is pressed, the stack of images shows up in the Source images window at the top right of the screen.

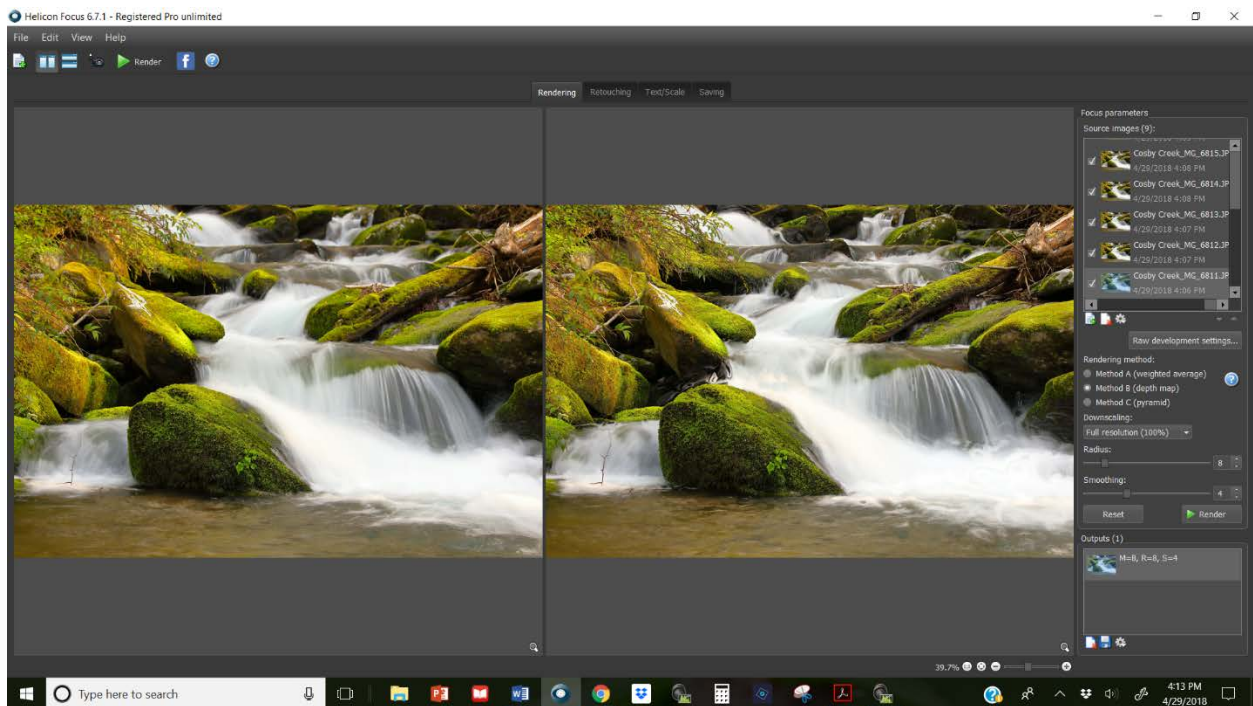


Figure 4 Once the source images appear, select a method - A, B, or C - and click on Render in the lower right side of the window to process the images. In other words, to stack the images and then press File again, and then Save to keep it.

Summary

Focus stacking enables you to cover far more depth of field and overall sharper images than previously possible. It is simply amazing to have enormous control over the depth of field. Although photographers tend to use focus stacking to get everything sharp, it also works the other way. Now you can use focus stacking to photograph a flower with lots of depth and get everything sharp. But, if you stop shooting the stack at the back edge of the flower, it is easy to keep the background completely out of focus. Indeed, by using $f/5.6$ to stack your way through the blossom, the background is far more out of focus than it would be if the flower is shot with a single exposure at $f/11$. Although most use focus stacking in close-up photography, it is incredibly useful in all types of photography anytime when photographing a still object. I use focus stacking for landscapes frequently and I can visualize situations where it is possible to use it in wildlife photography when the animal is motionless. It can be used with tilt-shift lenses, too. Image a field of dense tulips. Tilt the lens to make the plane of focus coincide with the plane of the flower blossoms. The stems go more out of focus because the plane of focus is closer to right angles with the vertical plane of the stems. Now focus stack your way through the stems to get them fully sharp up and down and merge all the images together for the ultimate in sharpness.

As times passes, I continue to discover new uses for this technique. Focus stacking is one of the most useful techniques that has become available during my forty-year photography career. Don't be left out! Go to the Zerene Stacker (www.zerenesystems.com) and Helicon Focus (www.heliconsoft.com) web sites, view the tutorials, and download the free trial software. Search the web for *focus stacking* articles, tutorials, and picture examples. Get started now and have fun!



Figure 5 Mingus Mill in Smoky Mountain National Park shot with a 24-70mm lens at 70mm. Exposure was $f/8$ at $1/4$ second with ISO 400. I used $f/8$ as that is a sharp aperture on the lens. This is a four shot focus stack and HDR combo. That means I was doing in-camera HDR while shooting the stack of images focused at different distances. I started the focus stack by focusing on the leaves at the near left side of the image and continued deeper until finally focused on the building. I used live view and autofocus. By touching the LCD screen, I changed the focus from near to far. And to eliminate vibration caused by touching the LCD, I set the camera to 2-second self-timer.