

The Miracle of Focus Stacking

Robert Stone February 2024

Early in my exploration of landscape photography I religiously consulted Zeiss formula tables to determine the hyperfocal distance for perfect depth-of-field. Failed images suggested that I could not accurately target hyperfocal distances by eye, so I started using a carpenter's laser rangefinder to find an accurate focus point. This mostly worked well, but failed when bright sunlight rendered the red dot invisible.*

The Zeiss formula promises that the DOF shown in the tables guarantees 'acceptable sharpness'. Unfortunately, at the hyperfocal distance, the near and far points of your image are at the edges of 'acceptable'. And I actually want better than acceptable! Some suggest focusing at twice the hyperfocal distance to assure that sharpness fully extends to the horizon. Both assume you can actually set focus *exactly* at this distance.

When I needed more depth-of-field than possible in a single image I started creating stacks. I reviewed each image on the rear LCD to identify the next focus point to manually refocus the lens. This did eliminate the need for the laser tool but was very time consuming when the starting distances were only a few feet away.

You have likely seen a number of YouTube videos where a landscape photographer creates stacks manually. They set the lens to f/16 "just to be sure", then pick 3 items in the scene, near, middle, far, to re-focus and shoot. This is a technique that is relatively fast; you should use it in simple compositions. It easily succeeds when using wide angle lenses at small apertures. But it often fails when the nearest part of the scene is just a foot from the lens and there are many intermediate distances requiring accurate focus. But then, diffraction reduces sharpness at f/16.

All this changed when a new Nikon model, the D850, introduced 'Focus Shift Shooting'. I found this phrase peculiar and prefer 'Focus Stacking'. (Sony calls it Focus Bracketing.) You only need to set up focus stacking in your camera's menu system once! The camera does all the tedious work. You simply compose and expose ... as you must for every image. Technical choices are eliminated, artistic choices get full attention.

This is the focus stacking miracle: Stacking literally builds depth-of-field for you. You only use your lens' sharpest edge-to-edge aperture. You focus on the easiest part of the scene, the closest. You no longer have to think about f/stops, depth of field, Zeiss tables (printed or a smart phone app) or acceptable sharpness. The problem of setting accurate focus at the hyperfocal distance or multiple focus points is gone. *Every DOF concern vanishes!*

Here's how simple it can be ...

- I always have the camera on a tripod, but this can be done hand-held in some cases.
- Make your usual exposure and composition assessments but use your lens' sharpest edge-to-edge aperture, typically f/8.
- Use Aperture Priority or Manual, ISO and Shutter as needed, continuous autofocus Off.
- Focus on the nearest part of subject.
- Invoke the Focus Stacking menu.
- Done!

This is the Focus Shift Shooting menu on my Nikon Z 7II:

- | | |
|-----------------------------|-----|
| 1) Number of shots | 20 |
| 2) Focus step width | 4 |
| 3) Interval until next shot | 0 |
| 4) Exposure smoothing | OFF |
| 5) Silent photography | ON |
| 6) Starting storage folder | OFF |

All items are set up once then mostly stay unchanged. Setting Item 1 to 20 works for almost all of my landscapes and often produces more frames than needed. (This is described in more detail below.) Changing item 3 may be necessary if working with flash and recharge time is needed. You might think that item 4 might be useful under

* Some newer carpenter's lasers use a green LED which may not suffer this problem. But keep reading ...

changing lighting conditions, but it generally does not work for reasons also described below. With the settings shown for the bottom four items, stacks are built remarkably fast, often in just a few seconds at typical shutter speeds.

Nikon's User Guide does not provide any help with the proper values for items 1 and 2. I established these by testing. The shallowest DOF issues I face are shooting 1:1 macro images using my 105mm lens. Choosing f/8 as this lens' best corner-to-corner aperture, I created stacks using different values for step width. I used LensAlign's 'ruler' as the subject. The Focus step width of 4 worked perfectly at this very challenging magnification. Note that shorter focal length lenses will have deeper DOF at a given aperture or at less magnification. The step value of 4 will always work at 1:1 or less!

Once started, the camera takes multiple images, automatically refocusing at increasing distance for each subsequent image. The stacking process stops when the preset number of images is reached, as set in the menu, or the lens reaches infinity.

Perfecting Stacks

On a recent image stack at 24mm, the camera took 10 images but only 4 actually needed. (Lenses may focus beyond infinity, compensating in part for changes in the lens' physical length with temperature.) This is not an actual problem! These extra images can be easily culled in post using LR or Bridge at 100% view. Start with the last image in the stack, then move back image-by-image toward the beginning of the stack until you find the image with best focus for distant items. Delete the out-of-focus images. (You will want to be cautious about this; always double check!)

I based my step width of 4 specifically for macro work. You may be able to find a more optimal step width for normal landscapes. Here's a simple test: After shooting a sequence at Width=4, try a second of the same subject at Width=5 and a third at Width=6. (Don't forget to re-focus on the near parts of the scene between stacks!) Place your hand over the lens and take a 'marker shot' between stacks to make it easier to find the stack groups in LR or Bridge. Stacks having a large expanse of flat, textured foreground (your lawn or a local park) make evaluating step width easier. Alternating bands of sharp and blurry texture will indicate a step width that is too big.

I have Exposure smoothing Off. This is due to a fundamental issue with stacks; mixed lighting and contrast mostly ruins stacks. In practice, the stacks are built so quickly that this option is not needed.

Here are two tips based on mistakes I made early on: First, the 'nearest' part of the image may not be readily apparent. One source of this is field curvature. Another is that objects at the edges of the image may actually be closer than the apparent object of focus. This can be difficult to see on the camera's LCD. After focusing on the nearest part of the image, I always manually re-focus the lens just a tad closer before invoking the stack; often this first image is a throw-away.

Second, the number of shots on the menu may be too few, stopping before infinity or the full depth of your subject is reached. Review your last stack images at 100% on the rear LCD. If you need more, just restart the stacking menu, *but do not refocus the lens*. This will correctly add additional images to the current stack.

Assigning to a Button

Your camera may allow assigning focus shift shooting to a button. My Nikon Z7II does not. However, one option for buttons is 'Top item on My Menu'. Simply place the Focus Shift Shooting menu item there for one button access!

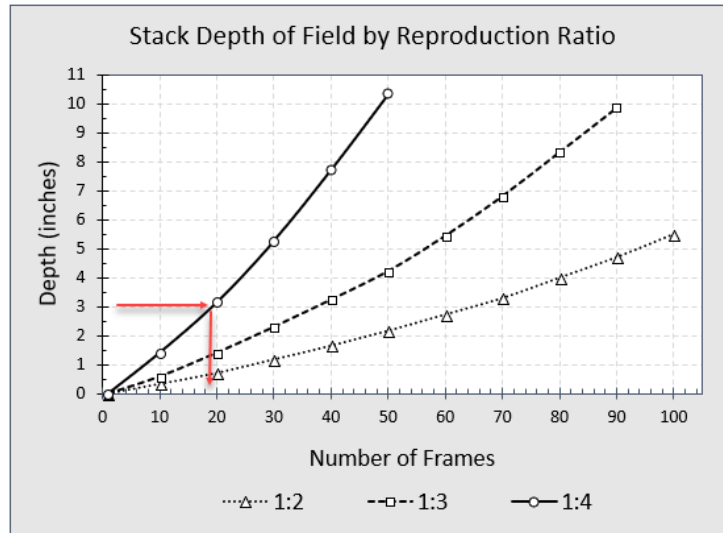
Stack Rendering

YouTube reviewers have complained that the camera does not render a final, stacked image. In fact, you do *not* want the camera to do this! All stacks have the potential for ghosting ... things in the image moving between shots, e.g. wind-blown reeds in a pond foreground. I use Photoshop and Helicon Focus to render the stacks. Photoshop renders stacks as layers and masks which can be edited to remove ghosts. Helicon Focus produces a 'finished' stack but has good tools to deal with ghosting.

There are situations where automatic stack creation doesn't work easily. Crashing ocean waves and strong winds provide for too much movement to get proper alignment in the stacked image. On the coast of Maine, I can usually find a way to create one frame manually that isolates breaking waves and can be blended into the final stack.

Deep Stacks

One other experiment I did with the LensAlign ruler was to build deep stacks. This allowed me to produce a chart showing the actual number of images needed to achieve a given DOF at various reproduction ratios. (The Nikon 105mm macro lens has reproduction ratio settings on the lens.) How this was done is the subject of a more detailed PDF. This screen shot of the chart shows that a 3" DOF at the 1:4 reproduction ratio would require 19 images. Just read across and down. And I would add few more 'just to be sure'. (I believe this will work for all 105mm lenses on any full frame camera.)



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