

Figure 1. *Phaeomarasmium erinaceus*.





# Photographer's FOCUS

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## Try focus stacking for mushroom photography!

Alison Pollack

Interest in mushroom photography has been, well, mushrooming in recent years. More and more people are venturing into the woods in search of mushrooms, while phone cameras and the new crop of mirrorless cameras make it easier to get high quality photographs of fungi. In this article, I discuss a particular photographic technique, focus stacking, that can be used to dramatically improve your mushroom photography. The article includes a review of what focus stacking is and the pertinent photography basics needed to understand it, camera gear for focus stacking, how to do stacking in the field, and a review of available software for focus stacking.

Warning! Focus stacking is an advanced photographic technique. To derive the most benefit from focus stacking, you'll need a good understanding of the basics of the "exposure triangle"—aperture, shutter speed and ISO—and your corresponding camera controls. You'll also need a fair amount of practice and patience!

### *What is focus stacking and what are its benefits?*

To understand the benefits of focus stacking, it is critical to understand aperture and depth of field. When you photograph a mushroom, the part you focus on will be in sharpest focus, but as you look in front of and behind that point, the focus becomes less and less sharp. The range between the closest and the farthest parts that are acceptably sharp is called the depth of field. In general, if you move away from the subject, the depth of field becomes larger, and if you move closer to the subject, the depth of field becomes smaller.

Most people want to create a photo that has the entire mushroom or mushroom grouping nice and sharp, but with the background less sharp. This brings more attention to the mushroom(s) and less to the background. On the other hand, you may also want to have the background sharp so that you can show the mushroom in its environment.

In general, there are two ways to get the entire mushroom or group of mushrooms (and from here forward I'll just say mushroom to mean both) in focus. One way is to control the depth of field using the aperture setting on your camera. Aperture is the adjustable opening of the diaphragm of the lens that not only determines how much light gets through to the camera's sensor, but also determines the depth of field. Aperture works like the pupils of our eyes. The wider the pupil, the more light comes in. Aperture is measured by a term called f-stop (or f-number). It can be a little confusing: larger f-stops have smaller apertures, with less light getting

through the lens, but greater depth of field. Conversely, smaller f-stops have wider apertures, and allow more light to reach the camera's sensor, but have smaller depth of field. Setting your camera's aperture to higher f-stops will give you more depth of field, but to get enough light for proper exposure you'll need to use a slower shutter speed.

While it is tempting to use the smallest aperture (highest f-stop) to get as much as possible in sharp focus, f-stops that are too high can cause *less* sharpness due to the optical properties of lenses. In addition, with narrower apertures, more of the background is in focus. If you want the background to be out of focus, that will mean using a wider aperture (smaller f-stop). While wider apertures are used to give a nice soft out-of-focus background, you may not be able to get the entire mushroom in focus.

The smaller the mushroom, the greater these challenges are. If you want to fill the frame with the mushroom, you'll need to get closer for smaller mushrooms. And, as stated above, the closer you get, the smaller the depth of field is. For very small mushrooms, even the highest f-stop will not get everything in focus.

The solution to these problems is focus stacking. Focus stacking is a technique that can be used to get the entire subject in sharp focus, while having a soft, out-of-focus background. A focus "stack" is basically a set of images with the focal point moved slightly from one image to the next. Enough images are shot so that every part of the mushroom is in focus in at least one. This creation of the "stack" is called focus bracketing. The actual focus stacking is done with specialized software that creates a



Figure 2. *Plicaturopsis crispa*.

composite photo with all of the in-focus portions of each image in the stack. The result is a photo with the entire subject in sharp focus and a softer, out-of-focus background. Figures 1–4 are examples of focus stacked photos. For the first three of those figures, I placed some nearby moss in the background to add nice contrasting color and also to cover distracting elements in the background.

### ***Camera gear and useful accessories for focus stacking***

You do not need to spend a lot of money to create focus stacked photos of mushrooms. It is even possible to focus stack with your phone camera. However, a good camera and lens will produce higher quality images for focus stacking. This is especially true if you want to focus stack very small mushrooms. I'll discuss here camera gear specifically oriented towards focus stacking and macro photos. In the two previous issues of FUNGI, there are articles by Edward Matisoff that describe in more detail options for photo equipment for mushroom photographers.

The most important thing in focus stacking is that the camera and the

subject are kept as still as possible. Focus stacking software aligns images before stacking, but that is properly done only if there has been minimal amount of movement. With greater movement the resulting composite photo may be blurry. While it is possible to take images for stacking without a tripod, you will get much better image alignment if the camera is on a tripod and your subject is not moving.

Focus stacking was made possible after digital cameras came to the market in the 1990s. There have been many advances since then, and there is a huge variety of options for photographers in today's market. If you want to try focus stacking with your phone, it is really only practical with a phone app, and preferably one of the many inexpensive small tripods that are available for smartphones. If you have an Android phone, there is an app called Open Camera that will automate the process of taking the stack of photos. I am not aware of a similar app for iOS devices.

If you don't want to spend big bucks on gear, the Olympus Tough TG camera is a good option for focus stacking. The latest version of the camera is the TG-6, about \$500 at the time this article was

written. If you want to use this camera to take photos of very small mushrooms, like tiny ascomycetes, get the Olympus LED macro ring light made specifically for this camera, as the camera needs to be very close to the subject, leaving little room for other lighting.

For the best image quality, but for more cost, use a Digital Single Lens Reflex (DSLR) or a mirrorless camera for focus stacking. DSLRs have been around for decades, but mirrorless cameras are now overtaking them in sales and capabilities. Mirrorless cameras are also smaller and lighter. If you are shopping for a camera, it will be helpful to buy one that has an LCD screen that flips up for easier viewing, since many of your mushroom subjects will be on the ground (Figure 5). Your back will thank you!

All of the major camera manufacturers now have mirrorless cameras with in-camera focus bracketing (to take the stack of photos) and focus stacking (to process the stack into the composite image), a great boon for macro photographers. The focus stacking is limited to a small number of images, but that may be fine for larger mushrooms. You'll get much more control if you use these systems for focus bracketing to





Figure 3. A young *Schizophyllum commune*.

create the stack and then process the stack separately on your computer using external software, as discussed below. In these cameras, you typically set the starting and ending focal point for the stack, as well as the step size for moving from one image to the next, or the total number of images to shoot. The step size in these in-camera systems is relative, a number from 1 to 10. The disadvantages in having too many steps are that computer processing times will be a little longer, and you'll fill your camera cards more quickly. But if your step size is too large, then you will see out-of-focus bands in the stacked image, which you definitely want to avoid.

You'll need to experiment with whatever camera, lenses, and f-stops that you use to determine the appropriate step size. The smaller the f-stop (the wider the aperture), the smaller the depth of field is and the smaller step size you will need. Do some experimentation starting with small step sizes and see what works best. On OM System

(formerly known as Olympus) mirrorless cameras (which is what I use), when the camera is shooting the stack of photos, you can see the progress on the camera's LCD screen. You can then set just the front starting point for the stack, watch the progress, and stop the shooting when everything that you want in focus has been included. This appears to be the case for Canon and Fuji mirrorless cameras as well. But with Nikon mirrorless cameras, the LCD screen goes dark while shooting a stack, so you have to guess at the number of photos needed for the stack. When the stack is complete, check the last photo to be sure that you have included everything that you wanted in focus.

Unlike mirrorless cameras, only a limited number of DSLRs have built-in focus bracketing. Nikon has it on their flagship model, the D850, though they call it focus shifting. For DSLRs without focus stacking, there are two options: software that incrementally changes the focal point by adjusting the focal

ring of the lens, and hardware, such as automated rails that physically move the camera closer to the subject in incremental steps. Software programs include Magic Lantern for Canon DSLRs, Helicon Remote for Canon and Nikon cameras, and CamRanger for Canon/Fujifilm/Nikon/Sony cameras. Check to see if there is a phone app from your camera's manufacturer; these are being frequently updated. Automated focus rails will support any camera. The Stackshot by Cognysis, shown in Figure 6, was the first on the market, and is still an excellent rail. A Chinese company named WeMacro has since come out with a competing automated rail that is significantly less expensive and almost as good. These automated rails need a power source. While they can be used in the field, you'll be adding a lot of weight to your pack not just for the rail but also a large battery to run it. Therefore, they are best used in the home studio.

Almost any lens will work to photograph larger mushrooms, either



Figure 4. *Polycephalomyces tomentosus* parasitizing the slime mold *Trichia botrytis*.



a fixed focal length or a zoom lens. To photograph smaller mushrooms, a specialized macro lens is best. The typical definition of a macro lens is that it shoots at 1:1, meaning the subject is the same size in real life as the image projected on the sensor. Every camera manufacturer makes a very good 1:1 macro lens, and there are also good, less expensive third-party macro lenses (e.g., from Sigma and Tamron). An added benefit of these macro lenses is that they are also very good as portrait lenses.

A full-frame camera has a sensor that is 36 x 24 mm. For this type of camera, a 1:1 macro lens will fill the frame with a subject that is 24 mm tall if shot in landscape mode, or 36 mm tall if shot in portrait mode. Full frame cameras generally have better image quality, and finer resolution, but they are more expensive than cameras with smaller sensors. Macro 1:1 lenses on cameras with a smaller sensor, called crop sensor cameras, will fill the frame with a smaller mushroom, which gives the



Figure 5. Getting the camera low to the ground with a tripod that has a center post that flips from vertical to horizontal.

effect of magnifying a subject more than a full-frame camera, though with less resolution (fewer megapixels).

To photograph small mushrooms and

still fill the frame, there are macro lenses that are 2X life-size, meaning that for a full frame camera the field of view is 18 x 12 mm. The Chinese manufacturer





Figure 6. Sunway manual focus rail (top) and Stackshot automated focus rail and controller (bottom). The Stackshot package also includes a power supply and a motor cable.

Laowa makes an excellent 2X macro lens, and also an “ultra macro” lens that goes from 2.5 to 5X. Canon also makes an “ultra macro” lens, the MPE-65, which ranges from 1X to 5X. All three of these high magnification lenses are manual focus, and therefore cannot be used for in-camera focus stacking. OM System has just released the first 2X macro lens with automatic focus, which can be used with OM System or any other micro four-thirds camera that has focus bracketing capabilities.

For shooting very small mushrooms, there are three possibilities for increasing the magnification of macro lenses even more—close-up diopters, extension tubes, and teleconverters. A close-up diopter, or close-up lens, attaches like a lens filter—it screws on to the front end of your lens. They can be found for less than \$20 in many sizes, but the inexpensive ones degrade image quality and are not recommended. A much better choice is one of the Raynox close-up lenses. I use the Raynox 250, which increases the magnification of your lens by about 2–2.5X (depending on your lens specifications), and sells for about \$80. It has very good image quality, especially considering the price, and is well-loved by macro photographers.

Extension tubes are hollow, metal or plastic tubes that are positioned between the camera body and the lens, and usually come in sets of two or three tubes. If you want to use them for in-camera focus stacking, be

sure to get extension tubes that have electronic communication between the camera body and the lens. Adding extension tubes to your lens decreases the amount of light to the camera’s sensor, so adjustments to exposure settings—wider aperture, longer shutter speed, and/or higher ISO—are needed. Extension tubes can be used in combination with a close-up lens to get even more magnification.

Teleconverters, like extension tubes, are placed between the camera body and the lens to increase magnification. OM System makes 1.4X and 2X teleconverters, which have more magnification than you can get from extension tubes, though there will be more loss of light and they are more expensive.

To achieve the additional magnification with extension tubes, close-up lenses, or teleconverters, you’ll need to move the camera even closer to the subject. The depth of field becomes smaller, and hence smaller step sizes will be required when focus bracketing.

Finally, if you really want to get crazy and photograph with great detail subjects as small as a few millimeters, such as tiny ascomycetes or, my favorite, slime molds, you can even adapt a microscope objective to your camera. This adds a whole new level of complexity and is beyond the scope of this article, but some web page references with very good information on how to do this are listed at the end of this article.

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**Figure 7.** *Mycosylva setosa*, a focus stacked photo shot at f5.6 (left), and a single mid-stack image (right).

While the set of images for focus stacking can be taken handheld, without any support system, you'll achieve consistently better results if you place the camera on a sturdy support. Since most mushrooms are on the ground, you'll need a camera support that allows your camera to be as low as possible to the ground. This can be as simple as a beanbag, or even an item of clothing crumpled up, but you'll achieve consistently better results with a tripod (Figure 5).

There are a huge number of tripods on the market. Tripods are made of either aluminum or carbon fiber. Carbon fiber is stronger and lighter, but also more expensive. Just be sure to get one that is sturdy enough to support your camera and lens(es). A tripod has two components—the legs and a head to which the camera is attached. To get the camera low to the ground, there are several options. You can get a tripod with legs that open flat on the ground, one that has an invertible center post, or one in which the center post can flip from vertical to horizontal. The disadvantage of inverting a center post is

that you'll need to operate the controls on your camera upside down, unless you have a phone app or other device to control the camera. A tripod where the center post flips from vertical to horizontal can be used to get the camera very low to the ground, by adjusting the legs to be different lengths and angles.

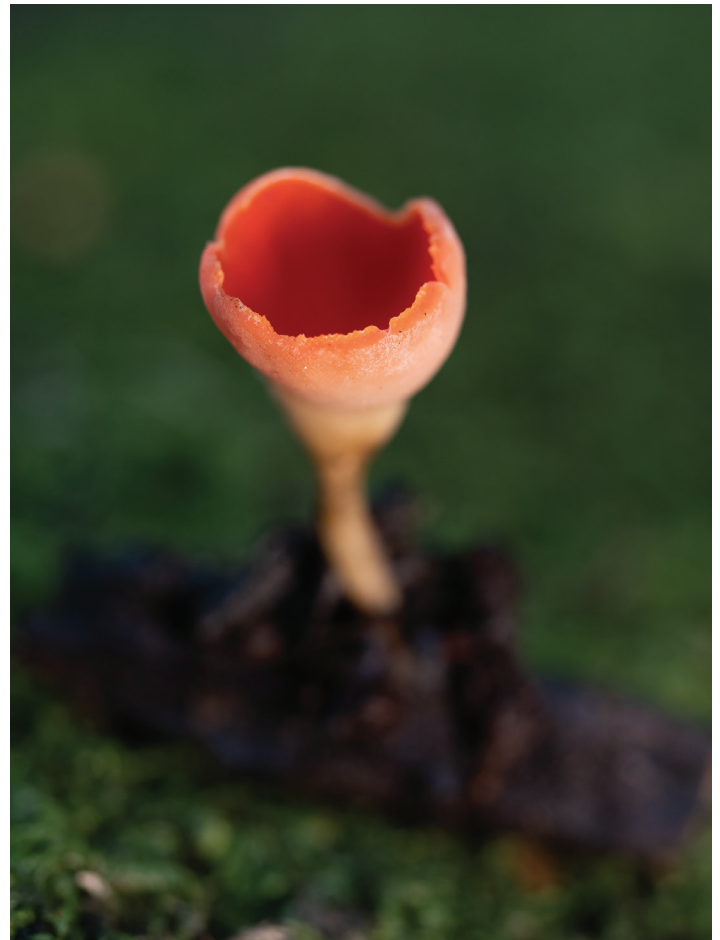
Some tripods come with a head that holds the camera, while for others you must purchase a head separately. I recommend a ball head, which easily and quickly positions your camera at any angle and rotation. When looking to purchase a ball head, check that it will support the weight of your camera, lenses and any accessories you use. Figure 5 shows my tripod and camera on the ground, with an LED panel for lighting the subject. The center post has been converted to horizontal to get the camera low to the ground to be able to photograph a cluster of myxomycetes (*Badhamia utricularis*, visible on the camera's screen) underneath the log. Also shown there is an LED panel on a small flexible tripod. With this type of tripod, the camera can also be placed low to the ground with the center

post horizontal with a combination of different angles and lengths of each leg of the tripod.

One other bit of gear that is very helpful with a tripod is to get an L-bracket for your camera. An L-bracket fits snugly to your camera, and allows you to very easily switch from a portrait to a landscape orientation. It's best to get one that is made specifically for your camera, so that you always have access to the battery and other compartments.

Lastly, let's talk about lighting, which could be the subject of an entire article, but I'll be brief here. There are two choices for artificial lighting—flash, and continuous lighting using LED light panels. Some photographers swear by flash, and some use only LED light panels. Flash units are expensive, especially the manufacturer-branded ones, but the flash units made by Godox are excellent and well-priced. LED light panels have really advanced in the last few years, and now you can buy very good ones for the price of a dinner out. Ulanzi wand lights, for example, are inexpensive, have a nice even light with a built-in diffuser, and have color





**Figure 8.** *Sarcoscypha coccinea*, a focus stacked photo shot at f2.8 (left), and a single image from the front of the stack (right).

adjustments. When using artificial lighting, it is best to light from the side, and to use some form of diffusion to avoid harsh bright light. When you do use artificial light for focus stacking, it is wise to take one stack with natural light and one with artificial light. One will usually be better, and it's not always obvious in the field which one it will be. Also try different levels of artificial light—sometimes just a little is good, but you won't know unless you experiment. Note that more artificial light tends to give darker backgrounds, especially when using flash.

### *Shooting the images in the focus stack*

Before taking a stack of images, or even single images for that matter, be sure that your camera lens is clean. Get into the habit of checking the front of your lens before shooting, with a light and magnifying glass if you have one. If you're out for a long day, this is best done several times over the course of the

day, especially if it is windy, when dust can easily be blown onto the front of your lens. Dust on the camera sensor can also introduce artifacts in stacking, so it's best to get the sensor cleaned every once in a while.

In the field, take your time to prepare the scene. The more carefully you do so, the better your stack and composite photo will be. For a good focus stack, everything must be static, not just your subject, but also anything in front and behind that you want in focus. If it's a windy day, it's not a good day for focus stacking! If your subject has any stray matter on it, like dirt on a mushroom, consider cleaning it, especially larger particles. I carry very small paint brushes and tweezers to help clean my subjects. Dirt that you cannot easily remove in the field can be cleaned up in post-processing if you wish. Be sure to also look closely for and remove any distracting elements in front of or behind your subject.

Once the scene is ready, position your

tripod and camera. Compose your shot a little wider than you normally would because some of the outside edges of the frames will be cropped when the images are aligned and scaled for stacking. Fix your exposure settings, in full manual mode, so that the settings are consistent across all photos in the stack. It's always best to use the base ISO of your camera, as higher ISOs can introduce noise. As for aperture, every lens has a "sweet spot" where the lens is sharpest, usually two or three stops above the widest aperture. For a softer background, though, use a wider aperture. In the field, I will frequently stack at different apertures, so I have some choices for the composite photo. Set your shutter speed to get the best exposure, one that does not blow out any of the highlights. It's good practice to use the histogram to preview the exposure and to set your shutter speed so that the histogram does not touch the right side; if it does it means that there will be overexposed white areas in the image where you



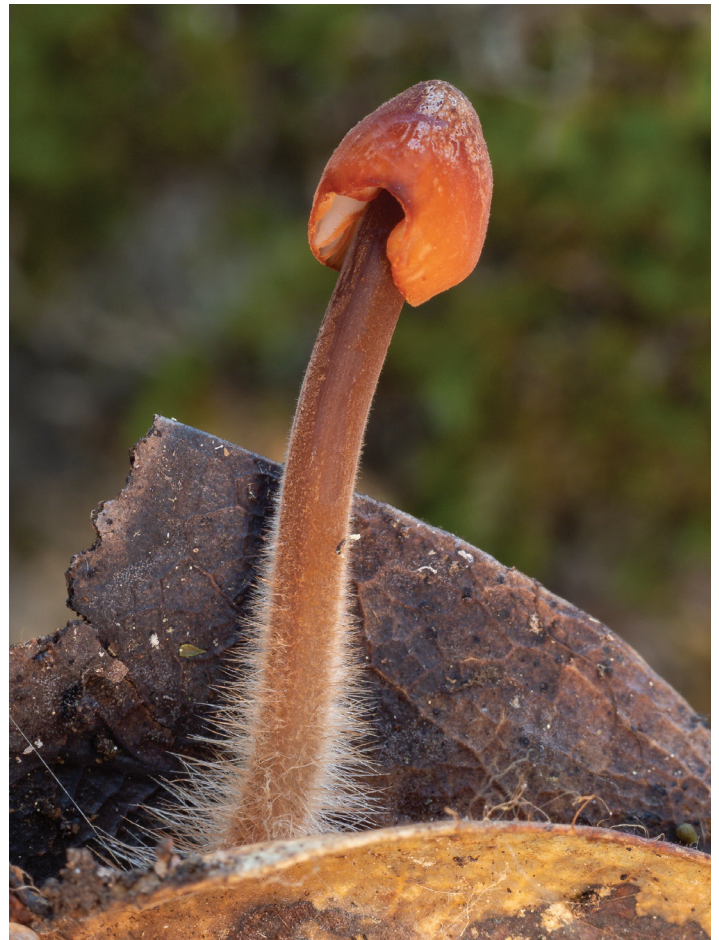


Figure 9. *Mycena californiensis*, a focus stacked photo shot at f3.5 (left), compared to a single photo shot at f9 (right).

will not be able to recover any detail. Take a test shot and check the output histogram carefully. If you are using artificial lighting, take test shots with that. If you're using flash, be sure the flash is also in manual mode so that the light intensity is the same across all of the images in the stack. If you are using a DSLR, use mirror-up mode if you have one, to minimize vibration effects.

If your camera does not have built-in focus bracketing, there are many ways to take the stack of images at different focal lengths. Manual stepping can be done by simply rotating the focus ring a little between shots. To stack this way, some experimentation and practice (and patience!) will be needed to learn how much to rotate the ring (depending on the lens and aperture setting) and how to do so consistently.

Manual stepping can also be done with the aid of a manual focus rail with a screw drive; there are good ones available for less than \$100. An example of such a rail is shown in Figure 6. Many articles about focus

stacking say you must have a focus rail if your camera does not have in-camera focus bracketing. This is true for high magnification stacking, above about 2.5X, but with a normal 1:1 macro lens and with a Raynox and/or extension tubes, you can easily stack manually just by rotating the focus ring. It just takes practice, patience, and a steady hand.

Take the shots from front to back and make your steps small enough so that there is some overlap from one shot to the next. Use either a remote shutter release or a time delay on the camera to avoid blurred images from camera movement when you press the shutter release. To start the stack, focus on what you think is the front of your subject, and then pull back a little bit, so there are extra shots in case you missed seeing something in front. Likewise, take more shots than you think beyond the back part of your subject. It's easy to later delete unnecessary shots, but you'll never be able to go back and get more shots if you missed something that you wanted in focus.

Proceed in the same manner if you have a camera with in-camera focus bracketing. Set your starting point for the stack slightly in front of your subject, and the ending point slightly behind your subject. Use a remote shutter release or a timer to start the stack. Pay attention to the foreground in the scene. It's usually more pleasing to have the foreground in focus rather than blurry, so start the stack with the foreground in focus. Then you have the option to have the foreground in focus or not, by using or not the images with the foreground in focus when you feed the images to the stacking software.

The best conditions for photography are a cloudy day, with no direct sun. Under those conditions, the light is well-diffused and soft. If you want to photograph a mushroom on a bright sunny day, it's best to put your body, or your backpack or something else to block direct sun from hitting your subject. You can also use a diffuser, but in bright sunlight even diffusers may not soften the light enough and the light on the subject





Figure 10. Three different fungi on moose dung, a focus stacked photo shot at f3.5 (above), compared to a single photo shot at f9 (below).



may be harsh and uneven if the sun is moving in and out of clouds or trees.

Much of mushroom photography will be done in the forest, where the light is low or dappled. Here too it is best to block any direct sun from reaching your subject. In the forest there may not be enough light to get a good exposure, so some type of artificial lighting may be needed. You can change your exposure

settings—for a given aperture, you can use longer shutter speeds or higher ISO—but these will both introduce some noise, so artificial lighting will help.

Always review the photos in a stack when you are done shooting, to be sure that everything that you wanted to be in focus is there. This is especially true for cameras whose LCD screen goes dark while taking the images—you

won't know if the stack went far enough to include everything you wanted; if it didn't you may need to extend or redo the stack. Check to see if anything distracting was included that you didn't notice when setting up the shot, and, if needed, remove it and redo the stack.

Figures 7 and 8 show two examples of a focus stacked photo, compared to a single image from the stack. In the mid-stack image of the *Mycosylva setosa*, shot at f5.6, you can see some fruiting bodies are in focus, but others in front and behind are not. The single image for the *Sarcoscypha coccinea*, shot at f2.8 to get as soft a background as possible, shows how little is in focus in a single image in the stack.

Figures 9 and 10 show two examples of a focus stacked photo, compared to a single image shot with a narrow aperture. In the single photo of the young *Mycena californiensis*, shot at f9, the background is soft, but still somewhat distracting. The focus stacked image of the same mushroom, shot at f3.5, not only has a much softer background, but also sharper detail in the mushroom and the leaves. Figure 10 shows three different fungi on moose dung, shot in Alaska where this is colloquially called a “moose nugget.” The fungi are very small, and the photos were taken with both a Raynox 250 and extension tubes to increase the magnification of my 1:1 macro lens; with such high magnification the depth of field is tiny. Here too, the single photo, taken at f9, is not very detailed and has distracting background elements. The focus stacked image, shot at f3.5, has sharp detail for the entire subject, and a nice soft background with no distracting elements.

### *Focus stacking software*

Once you have your stack of photos, it's time to create the composite photo with focus stacking software. There are several options from free to commercial software, but if you intend to do a lot of focus stacking, the best choice is definitely one of the two dedicated commercial software packages—Helicon Focus or Zerene Stacker. Both of these are well established, popular, and will do an excellent job on most stacks. Both are available for Windows and Mac computers, and have good on-line



tutorials that clearly demonstrate how to use the software.

There are, however, some significant differences to consider. The biggest advantage of Helicon Focus is that it is significantly faster, as it uses the capabilities of the graphics processing unit (GPU) on your computer while Zerene does not. The user interface for Helicon is a little easier to use than Zerene's and is thus easier to learn, but that is because there are many more options in Zerene. Also, if you are shooting RAW, Helicon will convert your files to TIFF for stacking, while for Zerene that conversion must be done outside the software.

Zerene has a steeper learning curve, but more functionality, and has richer and more detailed color rendition. Artifacts can occur with focus stacking, such as halos around subjects, and retouching is sometimes required to fix them. Both packages have retouching tools built-in (and good video tutorials for how to do so), but the retouching tools in Zerene are far superior. Zerene has an enormous amount of

documentation and help files, while the documentation for Helicon is much more limited. Lastly, the support from Zerene is outstanding. The developer (one person in Washington State) is extremely responsive to all questions; he not only responds quickly, but usually gives you more information and help than you were asking. Helicon, on the other hand, is slow to respond and the answers are less helpful.

Both packages have user forums, but the Zerene forum is by far the better, more responsive, and more informative of the two. Both Helicon and Zerene have very good integration with Lightroom, and can be run from within Lightroom. As stated above, Helicon does the conversion from RAW to TIFF, but if you use Lightroom, the Zerene plug-in does the RAW to TIFF conversion in Lightroom and then passes the TIFF files to Zerene. Photoshop can also do the RAW to TIFF conversion. If you do not use Lightroom or Photoshop, there are many options to convert from RAW to TIFF; the best would be to use the software from your camera manufacturer.

Both Zerene and Helicon offer a one-time purchase with free lifetime upgrades—\$89 for the basic version of Zerene and \$115 for the basic version of Helicon. Note that retouching is included in the basic version of Zerene but you'll need to purchase the higher priced Pro version of Helicon to get their retouching tools. I highly recommend that you take advantage of the fully functional free 30-day trials available for each, and see which works better for you.

Photoshop can do focus stacking (also as a plug-in from Lightroom), but the functionality is very limited, the quality is nowhere near what you get with Helicon or Zerene, and retouching is extremely difficult unless you have a very small number of images in the stack. I do not recommend Photoshop for stacking.

There are free options available for focus stacking, such as Picolay (some instructions in German) and ImageJ, but I have not used them. CombineZP is older free focus stacking software, but there has been no update or support for it for many years.

Hopefully, I've provided you with



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enough guidance here to understand what focus stacking is, why it's helpful, and how to start trying it yourself. It's fun to do and it's amazing how much your mushroom photos can be improved by using it. Keep in mind that it takes practice, and a fair bit of patience, to create stacked images with nice soft backgrounds, but it is totally worth the effort!

### **Online resources for learning focus stacking**

Until recently, there were few online resources for focus stacking, but now there is a wealth of very good information available online. Here are some useful links. Helicon Focus and Zerene Stacker video tutorials and articles on their websites:

<https://www.heliconsoft.com/helicon-focus-tutorials/>  
<https://www.heliconsoft.com/faq-helicon-focus/>  
<https://zerenestacker.com/cms/stacker/docs/tutorials/tutorialsindex>

<https://www.zerene.com/cms/stacker/docs/faqlist>

The tutorial videos are brief and will help you to quickly run the software. The Zerene web page, though, has much more depth of information on all aspects of focus stacking.

Free stacking software:  
<http://www.picolay.de/>  
<https://imagej.net/ij/index.html>  
Automated focus rails:  
<https://cognisys-inc.com/focus-stacking/stackshot-pkgs.html>  
<https://www.wemacro.com/>  
A recommended manual focus rail:  
[https://www.sunwayfoto.com/e\\_goodsDetail.aspx?gId=1425](https://www.sunwayfoto.com/e_goodsDetail.aspx?gId=1425)

This rail is available at many online sellers (e.g., Adorama, B&H, Amazon).

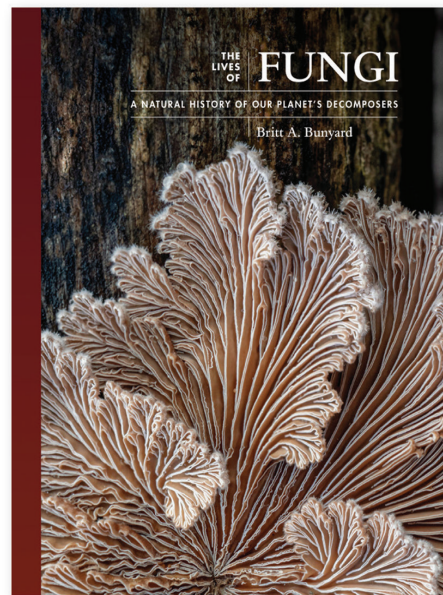
### **Informational websites:**

<http://extreme-macro.co.uk/> is an excellent website chock full of terrific information on focus stacking techniques and equipment. If you are interested in learning focus stacking, I suggest that you start here, and read as much as you can. It can be a bit overwhelming at first, so start with the basics and go back and read more as you are learning and practicing.

If you want to try your hand at focus stacking for extreme macro photography, loosely defined as 5X magnification or greater, there is an excellent series of lengthy in-depth video tutorials available at <https://www.youtube.com/@AllanWallsPhotography/videos>.

Another excellent resource for close-up and extreme macro photography is the website <https://www.photomacrography.net/>, led by the developer of Zerene Stacker. There you can search for topics in the extensive technical forums, and peruse the galleries to see exceptional macro and micro photography. Questions posted to the technical forums usually get very quick and helpful responses from experts.

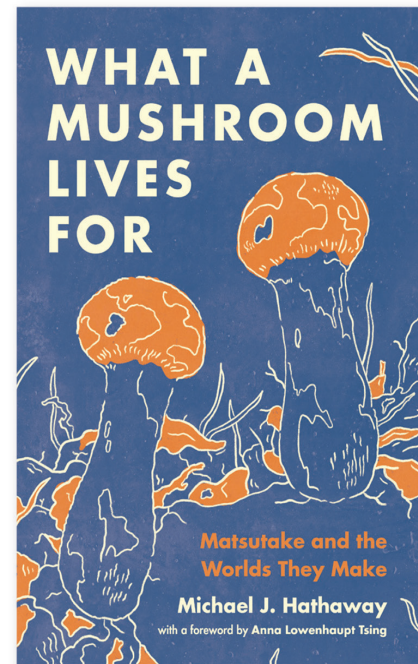
*Alison Pollack is an award-winning photographer. Her latest honor came from the prestigious Nikon Contest where she took 5th prize in 2022. She wishes to thank Alan Rockefeller for providing input, and for helping many people improve their mushroom photography through his talks at mushroom fairs and forays. Alison Pollack and Alan Rockefeller will be teaching a five-day class in mushroom photography at the Madeline Island School of the Arts in September, 2023. See the ad in this issue for more details, or go to [www.madelineartschool.com](http://www.madelineartschool.com).*



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