A Practical Approach to Depth of Field

The Rule of 32, by Tim Knapp

Traditional approaches to depth of field attempt to bring scientific precision to the vague notion of range of acceptable focus, yet most modern cameras only allow adjusting that depth of field in roughly 10% steps. How much precision do we really need for a vague idea with a coarse control?

Traditional approaches to depth of field also typically use a variable that is only knowable under the most controlled of situations, and even then introduces a serious complication. What is the distance to the subject? How can we possibly know it? And where exactly do we measure from on the camera side?

Smart photographers have always recognized that through simple geometry, we can estimate a distance to the subject simply by knowing the focal length and some estimate of the size of the focal plane as captured. We can often easily estimate the size of the focal plane as captured because we typically know something about the size of our subject. What if we eliminated the need for this additional calculation and simply used this estimate of the focal plane as our input variable?

By stepping away from the desire for scientific precision and changing our input variable to something more easily directly estimated, we can derive an interesting and simple empirical relationship:

$$A\# \times SS \times SS/DOF = 32 \quad \text{(the DOF rule of 32)}$$

Where:

A#=Aperture number (or equivalent aperture number for sensors other than 24X36mm)
SS=Short side dimension of captured portion of focal plane in feet
SS/DOF=Ratio of short side dimension to depth of field

If we start by looking at all the cases where the short side dimension is equal to the depth of field, we set SS/DOF=1 and the formula simplifies to:

$$A\# \times SS = 32 \qquad \text{(when SS/DOF=1)}$$

Because the curve fitting coincidentally works out to almost exactly 32 when using the short side dimension of the focal plane and units of feet, our life as photographers (well, at least American photographers comfortable working in feet) couldn't be any easier. 32 is a power of two and photographers know powers of two. We actually have a calculator built into our aperture dial. Let's start with the little-known fact that 5.6 times 5.6 equals 32. That means that for any chosen aperture value, we can count the number of clicks it takes to get to 5.6, and then continue beyond 5.6 the same number of clicks and we will land on the short side dimension where the depth of field is equal to that short side dimension for that starting aperture value. It doesn't require the aperture dial, though, to quickly recognize that f/4 will give us 8 feet of depth when our short side dimension is 8 feet or that f/3.2 will give us 10 feet of depth when our short side dimension is 10 feet. The aperture dial trick is more useful for pairing up the values that are less immediately mathematically obvious (e.g., 6.3 and 5, 7.1 and 4.5, or 2.8 and 11).

This simple relationship also allows us to do something practical that we never really could do before. We can now calculate an aperture number to achieve our intentions. And isn't photography really all about achieving our intentions? If we simply estimate our short side dimension in feet to the nearest common aperture number, we can now quickly find the aperture number where our depth of field will be equal to our short side dimension. If we want less depth of field or more depth of field, we can then simply factor the aperture value. Half the aperture value will give us half the depth of field. Double the aperture value will double the depth of field. If we only want to tweak a little, each third of a stop will change our depth of field by about 10%.

Those paragraphs were actually quite demanding reading, so let's look at one simple example to illustrate how easy practical depth of field now becomes. If we encounter a fox, most amateurish photographers will be so excited that they simply start shooting with whatever settings they had in the camera for last night's sunset. Calmer more-experienced photographers can now start estimating. A fox stands a couple feet tall and we usually frame them with at least a little dead space above and below. We might spend a few seconds arguing with our self about whether the short side dimension of our viewfinder view is 2.8 feet or 3.2 feet, but we have dialed this in rather quickly to within a third of a stop. We know instantly (or we sit and count clicks on our aperture dial for a couple seconds) that we will get roughly the same depth as that short side dimension if we dial f/11 or f/10, depending on where we landed in that argument with our self about the short side. If the fox were in a full profile view (more of a partial in sample photo), we might be willing to tolerate shallower depth of field in the interest of maximizing our shutter speed or reducing our ISO. Half should be easily tolerable so even f/5 would work, giving us 1.6 feet of depth for a 3.2 foot short side dimension. If we were shooting with a Canon APS-C body, we simply dial 4 clicks wider to get to the equivalent aperture, landing on f/3.2, provided our lens is fast enough to go that wide. If we set an f/2.8 lens wide open on that camera, we will get about 17 inches of depth (1.6 feet is about 19 inches and then minus about 10% for the third of a stop change from f/3.2). And with that, we have just dialed in a desired depth of field and landed easily within a third of a stop of scientific precision without ever using a calculator.

Let's review those steps for finding an aperture that provides adequate depth of field. First, we estimate the short side dimension in feet to the nearest standard aperture number. Second, we jump quickly to the aperture number where the depth of field will be the same as that short side dimension.

Third, we adjust or ratio that aperture for our real depth of field needs. Finally, if we are using a sensor size different than 24X36mm, we make the necessary adjustment (e.g., four thirds of a stop wider for Canon APS-C, six for micro-four-thirds, and a slightly complicating 3.5 for Nikon's 1.5 format).

The key to this process is starting with an estimate of the short side dimension. As we start thinking in terms of this short side dimension, we will find that we can now also now easily look at other people's photographs and make some judgements about good settings for the situation and possibly even make some estimates of the actual settings used or even the amount of cropping that must have been involved in the final image (inexplicably deep implies heavy cropping).

There are limitations to this approach. We cannot use this for very large subjects like mountains or perhaps buildings. The size of the subject that gives us a problem depends on the focal length used (wider angle lenses are more problematic) and on the aperture number being used (larger numbers, smaller apertures, are more problematic). For the scientifically inclined, this method starts underestimating depth of field by about a third of a stop when we reach 1/3 of the hyperfocal distance. For those who like the beauty of estimates rather than the cumbersome scientific hyperfocal distance formula, the technique reaches an underestimation error of about one third of a stop when our short side dimension is roughly the focal length divided by aperture number. For example, we can use this approach for a 50 mm lens at f/4 reliably up to a short side dimension of about 12.5 feet but we can use it for a 200mm lens at f/4 up to short side dimensions of about 50 feet. It is easy to see that super telephoto wildlife photographers really don't need to worry about this limitation, even when shooting at f/10.

The major error associated with the method is underestimation of depth which probably rarely hurts us anyway. That error will grow as we go beyond the limits described above simply because this formula doesn't recognize that depth of field for any lens reaches infinity at a less than infinite subject distance. For most practical subjects where depth of field is going to matter, this calculation is remarkably precise and usable, far better than the coarse 10% adjustments that come with each click of the aperture wheel.

This estimation technique correlates to using a circle of confusion equal to roughly 1/1500th of the diagonal. If you don't really know what that means, don't worry about it. If you do know what that means and you don't like that standard, you can scale accordingly, perhaps dialing the aperture a click or two as a final tweak to achieve your personal acceptable focus standard.

A few less-experienced photographers will be wondering why focal length isn't included in the calculation. Experienced photographers already understood that it doesn't really matter to depth of field. What matters is simply how tightly the subject is framed and what aperture ratio is used. By leaving focal length out of the equation, we eliminate the confusing implication of the traditional approaches that we could somehow magically increase the resolution of details by using a wider angle lens.

In practice, few are really going to use this simple math to calculate their settings in the field, but thinking through this math on a routine basis will drive home one very important reality of photography; larger subjects present less depth of field challenges than smaller ones. To put it another way, elephants are much easier to shoot than mice. The math actually puts some interesting boundaries on our world of photography. For example, when shooting short side dimensions of less than a foot, we can quickly see that we are forced to choose between diffraction and depth of field destroying the details of our subjects. Even at two feet, we still typically find ourselves in that dilemma. That dilemma is always made worse by the available light introducing slow shutter speed blur or high ISO noise as additional destroyers of details. Experienced small bird photographers already intuitively understand this choose-your-poison reality, but this math should allow even them to gain deeper quantitative understanding of one part of the compromise.

The four step method described above for finding an aperture is actually quite practical, but the simple rule of 32 can be arranged in many other ways to provide simple quantitative understandings never before available. For example, rather than locking in the ratio at 1, let's lock our short side in at 4 feet and rearrange the formula to this eye-opening relationship between aperture and depth of field:

$$DOF = A\#/2$$ (when SS =4 feet, DOF will be in feet)

All photographers who desire to dial in depth of field should gain from the understandings that this simple formula can bring. It doesn't matter if you shoot products in a studio, portraits in the field, or wildlife, this formula is much easier to work with than our standard cumbersome scientific approaches. This formula is so easy, the math can be done in your head and the results are more than accurate enough for our real needs.