Ely Photographic Club

DEPTH OF FIELD

Depth of Field is affected by five things: the exposure setting, the distance to the subject, the distance behind the subject, the length of the lens and the size of the camera sensor.

Aperture

Generally, no matter the camera, a wide-open aperture will give the shallowest depth of field. Therefore, an aperture of f/2.8 will give a very shallow / narrow depth of field and an aperture of f/22 a wide / deep depth of field.

However, an aperture of f/22 will introduce 'diffraction' which softens the image and is therefore not good.

The aperture of a lens, quite simply, is the opening through which light passes into the camera. The wider the opening, the more light can reach the camera sensor, which in turn affects the exposure of the image.

Just as the pupil in the human eye contracts in bright conditions and expands in low-light environments, the aperture needs to decrease or increase to achieve correct exposure – that is, a clear image that's not too dark or too washed-out – in different lighting conditions. This narrowing and expanding is done by an array of aperture blades in the lens that move synchronously to adjust the size of the aperture, up to the maximum that the lens is mechanically capable of attaining (which is the number in the name of the lens).

Aperture is expressed in f-stops. Confusingly, the f-number is not the actual size of the aperture, but has an inverse relationship to it:

aperture diameter = focal length (f) divided by f-number

This is why f-stops are written with a slash, as in f/1.4 and f/16 – they are actually fractions. It also explains why the lower the f-number is, the larger the aperture – the f-number is the denominator of the fraction, and 1/4 is bigger than 1/16.

Each increment on the standard f-stop scale halves the amount of light that reaches the sensor – f/4 lets through half as much light as f/2.8, f/5.6 half as much as f/4, and so on. Each of these steps, halving the amount of light each time or doubling it going the other way, is described as one stop of light. In turn, this is why the f-stop scale comprises the numbers it does, such as f/2.8 and f/5.6, instead of whole numbers, which would not correspond to whole stops of light.

Lenses

The other thing that has a large impact on Depth of Field is lens length.

A longer lens will provide a narrower depth of field than a wide-angle lens using the same aperture / f stop

Wide angle lenses have a greater / deeper depth of field primarily because they have a shorter focal length, which provides a wider field of view and lower magnification.

This reduced magnification means that objects at different distances appear sharper enabling the foreground and background to both be in focus.

The other reason in practice is photographers use wide angle lenses to capture larger scenes such as landscapes, where everything is farther away from the camera, but they also use smaller f/stops.

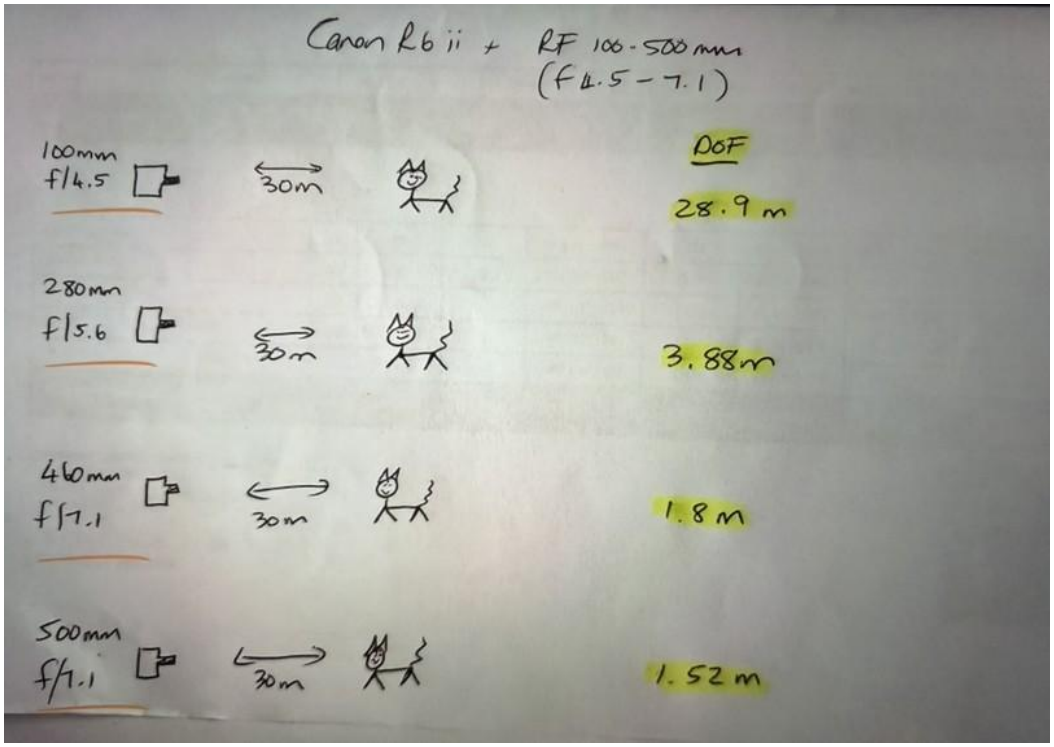
Conversely, telephoto (longer) lenses have a shallower depth of field because they magnify the subject and the background.

Telephoto lenses generally have a larger front element which increases the angle of the light this is explained in the Gerald Undone video mentioned later in this document.

This is why using a 600mm full frame lens can give that narrow depth of field especially when used at f4. This applies to some degree even when the f stop is increased (See Videos noted below).

This diagram shows the DOF using different lens lengths and different f stops with a full frame camera and a zoom lens, but at the same distance from the subject.

Diagram 1



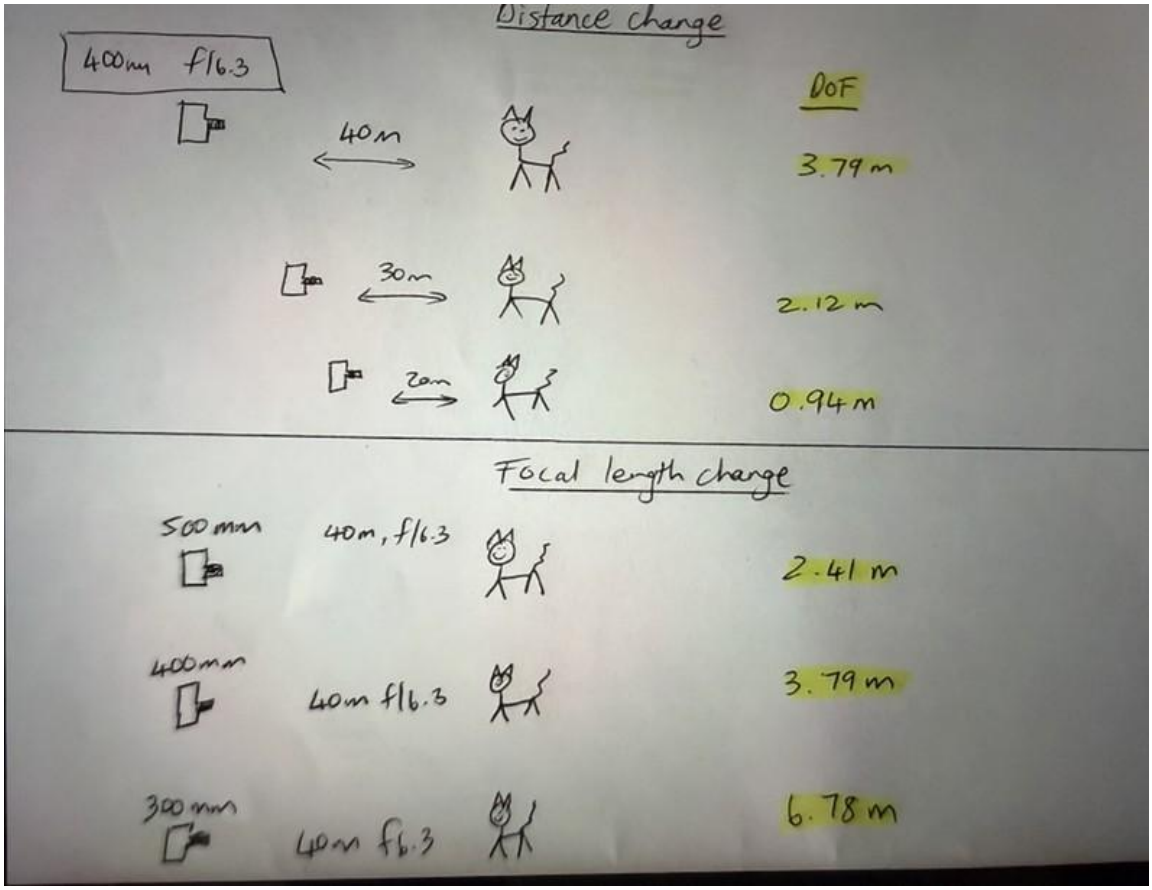
Distance to subject and focal length change

The top section of Diagram 2 below shows that the closer you are to your subject the narrower the depth of field, whatever the lens or f stop. In this case it shows this with 400mm at f/6.3 and reducing distances from 40m to 20m and the DOF reducing from 3.79m to 0.94m.

The bottom section of Diagram 2 below shows that at the same distance (in this case 40m) from the subject and at f/6.3 the longer lens provides a narrower depth of field. This is a very important point that is not that well understood.

500mm lens gives 2.41m DOF; 400mm gives 3.79m DOF; 300mm gives 6.78m DOF

Diagram 2



Of course, this applies to the subject as well as backgrounds, so on very large subjects you will require a deeper depth of field to get the whole subject sharp.

Then you may want the background to be soft and out of focus so it's often a balance.

Therefore, if you want a blurred background, you either need to be very close to the subject, or the background needs to be well outside the depth of field. The further it is behind the subject the better and softer it will appear.

As you can see from Diagram 1 even with an f stop of f/4.5 the Canon 100-500mm lens at 100mm gives a 28.9 m depth of field so the background would have to be a long way behind the subject.

At 500mm and f/7.1 the depth of field is only 1.52m so it's much easier to get the background out of focus.

Sensor size; Full Frame, Crop Sensor APS-C and Micro 4/3rd

This is why wildlife photographers often use crop sensor APS-C cameras as it gives a deeper depth of field which is great for birds in flight when there is nothing behind the subject other than sky.

The problem comes when the background is close to the subject and you want that soft out of focus background.

Effect of Sensor Size on Depth of Field

From Diagram 1 we can see at 460mm lens will provide a normal / standard depth of field on a full frame camera at an aperture of f/7.1 at a distance of 30m of approximately 1.8m (its normally considered 1/3rd of which is in front and 2/3rds of which are behind the subject).

A crop sensor camera has a crop factor of 1.5 or 1.6 depending on the camera make, so using a 460mm lens at f/7.1 is equal to roughly f/10 with the added depth of field this would give on the full frame camera. It doesn't impact the amount of light getting to the sensor, just the crop factor impacts the depth of field of the aperture / f stop.

Therefore, with a crop sensor camera to maintain a similar DOF to the full frame camera you would need a 300mm lens at f/5

A micro 4/3rd sensor camera has a crop factor of 2, so using a 460mm lens at f/7.1 would be roughly equal to f/14 with the added depth of field this would give on the full frame camera. Again, it doesn't impact the amount of light getting to the sensor just the crop factor impacts the depth of field of the aperture / f stop.

Therefore, with a micro 4/3rd sensor camera to maintain the same DOF to the full frame camera you would need a 230mm lens at f/3.5

This is why it's important to use a wider f-stop on both a crop sensor and micro 4/3rd camera if a narrow DOF is important. Don't follow examples where they use a full frame camera without taking into account the crop factor of your sensor.

Obviously, this is if you want a blurry / smooth background. If you want sharpness front to back, then crop sensor cameras and micro 4/3rd cameras have a deeper depth of field and therefore can be beneficial.

One genre where crop sensor cameras and micro 4/3rd Cameras come into their own is macro photography because the greater DOF helps here.

As this causes so much comment on the internet I have referred to a video below, which hopefully explains this much better than I have done.

Teleconverters

The other thing that affects apertures are teleconverters.

The 1.4x Teleconverter increases the aperture by 1 stop so an f/4 aperture becomes f/5.6, and a 2x Teleconverter increases the aperture by 2 stops so an f/4 aperture becomes f/8, but in both cases the depth of field is not affected.

Videos to watch

1. Take Professional Photos Without A Prime Lens (A clue : Depth Of Field) dated 13th December 2024 by C4 Photo Safaris (This is where the sketches come from)
2. For another good video of all of this watch the You Tube Video by The Slanted Lens dated 24 Apr 2024 titled “How Depth of Field Changes with Sensor Size - Camera Comparison”
3. Depth of Field Myths: Does Focal Length & Sensor Size Affect DoF? By Gerald Undone dated 28th September 2018

Examples

Tuscany: Taken in mid-May at 18:40 so it was getting quite dark, so I needed a slow shutter speed or a high ISO

As I was using a tripod, I could opt for a slow shutter speed and keep the ISO low. I needed focus front to back so needed a reasonably high aperture. As it's a landscape vista a reasonably wide-angle lens was used. The reason it was a 24-70mm lens is to avoid the distortion that you can get with ultra wide-angle lenses.

I took two shots as the foreground was quite dark and the sky was reasonably bright. Then blended them together in post. I also focused stacked by focusing on different places in each shot to help the front to back sharpness.

Settings: Aperture f/13, Shutter speed 1/15 sec for foreground & 1/80 sec for sky, ISO 100, Lens 24-70mm

Daws Heath, Essex: Taken at 16:55 at the end of May so the light was just starting to go.

I needed a moderately fast shutter speed as the fox was running across the grass, but I wanted a reasonably wide-open aperture to blur the background, but not so wide as to lose focus on the body of the fox. This meant a higher ISO was required.

Settings: Aperture f/6.3, Shutter speed 1/500 sec, ISO 2000, Lens 100-400mm

Distances: From subject 20m – 25m; From background about 70m

Probably got the aperture slightly wrong as the tail is slightly blurred but the face is sharp and that is the most important thing. I also liked the narrow area of focus in the grass so overall f6.3 was probably ok.

Green Farm Prickwillow: Taken at 09:54 in June so the light was ok

I had been using a fast shutter speed as the hares had been running around and when this one sat in the field boundary right in front of me, I had the wrong settings and no time to change everything, and this happens with wildlife.

It was the f-stop of f/7.1 that was the most important as it happened.

Settings: Aperture f/7.1, Shutter speed 1/2000 sec, ISO 800, Lens 600mm f/4 + 1.4xTC so 840mm

Distances: From subject 40m; From background 300m

Minsmere: Taken at 09:22 in April so the light was ok but not bright.

I needed a relatively fast shutter speed as although the Dartford Warbler was perched, they don't sit still. I chose a compromise which was probably not quite right as the background was just a bit too close behind. Probably would have been better with a slightly wider aperture.

Settings: Aperture f/7.1, Shutter speed 1/640 sec, ISO 160, Lens 100-400mm + 2xTC so about 800mm; The 2xTC increases the aperture by 2 stops to f/14 equivalent but Depth of Field is not affected.

Distances: From subject 15m; From background about 18m. The background was part of the gorse bush only about 3m behind the bird and being that close behind the subject isn't great, but this is where using a full frame camera with 800mm effective lens helps.

Peak District: Taken in September at 06:15 so it was very dark until the sun just rose over the horizon.

I was using a tripod so could go for a long exposure and keep the ISO low, but my shutter speed was dictated by the light. If it had been windy, it would have been a problem as then I would have wanted a faster shutter speed if the tree and grasses were moving, but it was still so that was ok.

I took two shots as the foreground was so dark and the sky was bright, then blended them together in post.

Settings: Aperture f/11, Shutter speed 1/30 sec for foreground & 1/320 sec for the sky, ISO 100, Lens 16-35mm (17mm actual). I took a chance with lens distortion but you can see the hill in the distance appears smaller than it really is.

I did use a filter for the sky shot (probably a 0.6 or 0.9 ND Grad) otherwise a faster shutter speed would probably have been required.

The problem with using filters is objects or mountains projecting above the horizon line, as we have here, so you must be careful. Given the improvements in editing software filters are being used much less but can still be helpful to avoid blowing out very bright areas of sky.

This is why a soft graduated filter can be better than a hard graduated filter in this situation.

Ouse Fen: Taken at the end of May at 06:32. The overall light was a little dark but with bright flashes at times so quite difficult to photograph a bird with a white breast and a very dark head. Technically this photo was a challenge.

Settings: Aperture f/5.6, Shutter speed 1/3000 sec, ISO 1000, Lens 400mm f/2.8 + 1.4xTC so effective length of 560mm and an aperture of about f/8 equivalent.

I was very close to the subject say about 10m away and the hedgerow behind this perch was quite close, so it was due to the closeness of the background I chose an aperture of f/5.6

As you can see the tail is not sharp just showing how even on a small bird the DOF wasn't deep enough. Should I have used an aperture of f/6.3 or even f/7.1 well I might have got the tail sharp, but the background may have become too distracting. Do I need the tail to be sharp as it's the eyes and the insects in the beak I wanted to focus on. It's always a balance.